POWER

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The Fireman

THE conversion of the energy potential in fuel to the energy of steam under pressure is a complicated and interesting process. Carried on, as it has been, by methods involving arduous manual labor in the grimy and sweltering conditions of the firing aisle or stoke-hole, there is little wonder that it has failed to attract a high grade of talent or to be conducted with much regard to technology.

The development of the mechanical stoker has changed all this. The coal is delivered mechanically into the hopper, the ashes are discharged mechanically into the cars that take them away. The job of the fireman has become one of the white-collar type. He reads gages, watches instruments that are continuously analyzing the gases leaving the furnace, to see how complete has been the process of combustion or how much air has been unnecessarily taken in to be heated to the chimney temperature and cool off the boiler. He speeds up or slows down the rate of coal feed, of air injection; regulates the thickness of the fire and adapts its performance to the demand upon it, by the manipulation of plugs and switches. He can make a difference of ten or twenty per cent in the efficiency of the station, simply by varying his manipulation of these knobs and cranks and levers.

The man in charge of the big turbines that eat up the steam that he is making, has nothing on him either in effort demanded or in the effect that he can produce.

And the fireman job, on account of the greater opportunities that it offers, of the more interesting processes that it involves, is becoming the more attractive.

The Chief spends more time in the boiler room and keeps track of the boiler-room records with much more interest than he used to. The CO_2 recorder, which is to the boiler what the indicator is to the engine and what nothing yet invented is to the turbine, has become popularized. Men of brains are sought as boiler-house foremen and superintendents, and the combustion engineer has become a power-house appendage rather than an isolated practitioner. Technical graduates find in the processes of the boiler room an excellent subject upon which to start in applying to industrial practice the principles they have learned.

And so the tables are turned, and the fireman, who of old was a sort of Man Friday to the watch engineer, is like Tubal Cain, the ironworker, invited to a seat beside the master.

F. R. Low

The Hartford Electric Light Company's South Meadow Station

Equipment Arrangement Particularly Adapted to Operating Convenience—Plant Laid Out for 130,000 Kilowatts in Five Units—Turbine's Guaranteed Water Rate 10.1 Pounds per Kilowatt Hour—Closed System of Generator Cooling—Boiler Operation Centered in Boiler-Control Room

EARLY in 1917, seeing that the practical limit of extension of its Dutch Point Station would soon be reached and that the growth of the load would demand a large increase in generating capacity, the Hartford Electric Light Co., Hartford, Conn., began acquiring property for the construction of a new station. The property is on the Connecticut River about a mile below the Dutch Point Station. It comprises a tract of over fifty acres admirably adapted for the development of a large steam-power station, with ample space for coal storage and for former any outside switching and trans- the distri- equipment that may be required for high volt- bution of large amounts of power at Webster, age. In the spring of 1919 Stone & with the Inc., were instructed to proceed the sta- preliminary work in the design of capacity, tion, and the first unit of 20,000-kw. and sev- with its condenser, was purchased, kw. unit, eral months later the second 20,000- bine unit with its condenser. The first tur- upon, the is now in operation. As decided an ulti- layout of the station is intended for units, al- mate capacity of 130,000 kw. in five can readily though the design is such that it be extended to twice that capacity. Sixteen boilers, of approximately 14,000 sq.ft. of water-heating surface each, are contemplated for the ultimate station, four of which are now being installed. They are arranged in a double row with the firing aisle parallel with the turbine room.

The relative elevation of boiler and turbine rooms was controlled by the fact that the Connecticut River is subject to heavy floods, the maximum difference in water level being slightly over 30 ft. In order to obtain water for condensing at periods of low water and at the same time provide against flood conditions, it was necessary to place the condenser floor 20 ft. below high water and make the portion of the turbine room below this level a water-tight concrete box. This required special provision against flotation and careful execution of the design to insure a tight job. The ashroom floor is at the level of the outside grade and above high water (see cross-section, Fig. 4).

Of interesting design and general arrangement is the turbine room. The only pieces of operating equipment at the floor level are the turbines themselves, all the auxiliary equipment being at the condenser-floor grade 25 ft. below. The main units are placed with their axes in one line and in the center of the turbine room. The turbine-room floor is in reality only a platform about four feet wide along each side of and about fifteen feet wide between the ends of the units (see Fig. 7). This fills all the conditions necessary for proper

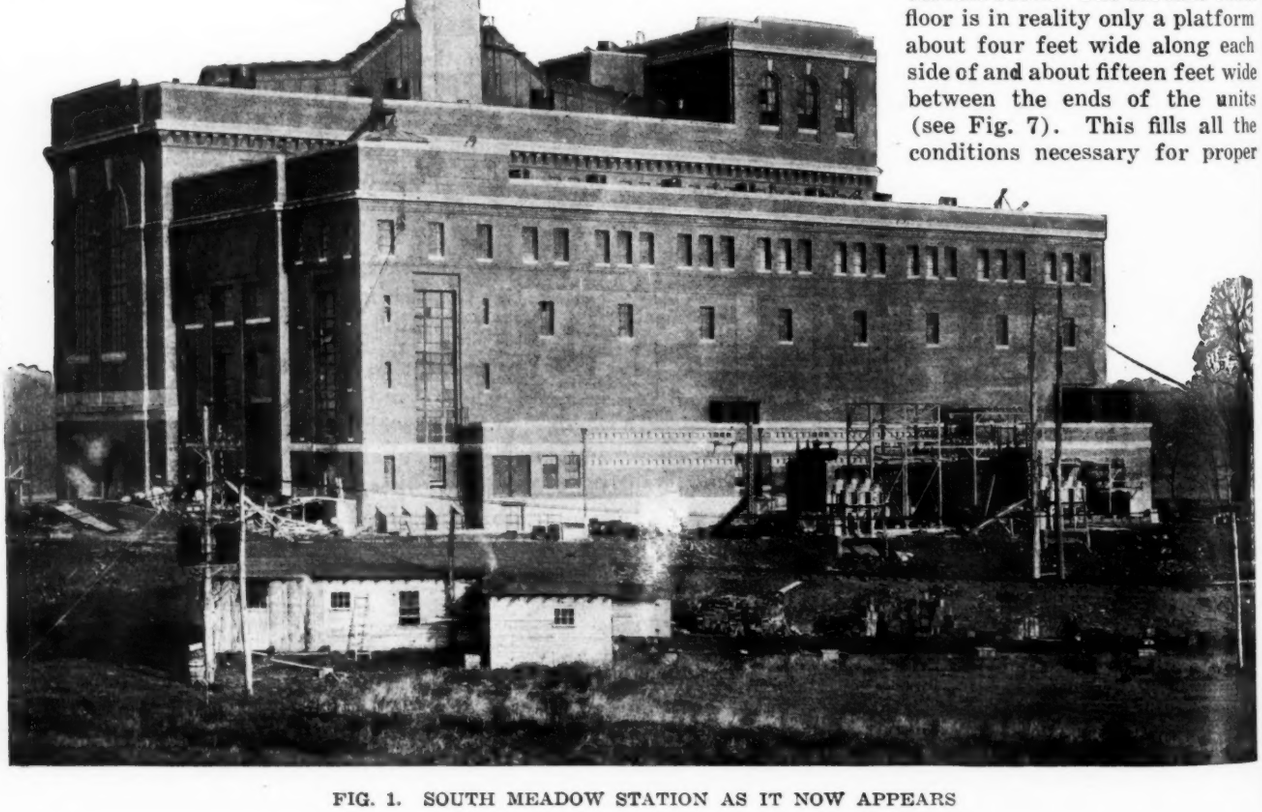

FIG. 1. SOUTH MEADOW STATION AS IT NOW APPEARS

operation and allows an abundance of light to reach the condenser floor, where most of the auxiliary equipment is located. All the auxiliary equipment is on the boiler-room side of the units, leaving the side next the electrical bay free of all apparatus. This

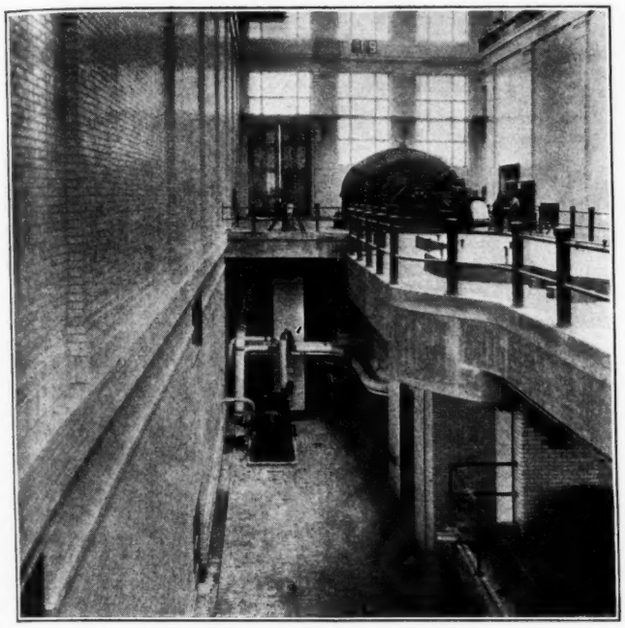

FIG. 2. TURBINE-ROOM FLOOR OPENS DOWN TO BASEMENT FOR CONVENIENT OPERATION

greatly simplifies the piping and assists in the dismantling of machines. All auxiliaries and equipment have been carefully placed with the result that the plant has extreme simplicity with the consequent ease of operation and maintenance. The present building has a ground area of only 0.57 sq.ft. per kw. In the ultimate station this will be reduced to 0.54 sq.ft. per kw. The cubical contents of the present building is 60 cu.ft. per kw. which in the ultimate building will be reduced to 56 cu.ft. per kw. While affording ample space around all equipment for its proper operation, the building is at the same time compact, showing that in the design no unnecessary space has been included.

A central bunker has been used, placed overhead and crosswise of the boiler room in the center of the ultimate plant and with traveling larries serving the boilers. This leaves clear space over the aisles for light and ventilation and gives a practical means of measuring the coal as used. There are no boilers under the bunker, the space being used for heaters, water-treatment equipment, elevators and other equipment (see Fig. 7).

For the initial development coal will be received by rail, and a standard-gage track has been laid circling the power station and inclosing a ground area sufficient for coal storage. This track is connected to a spur from the railroad company's tracks and passes over the receiving hoppers at the power station. It also contains an unloading trestle from which a standard-gage locomotive crane distributes coal to the storage pile. The locomotive crane, standard-gage cars and industrial steam locomotive reclaim and transport the coal to the receiving-track hoppers. Considerable money was saved by utilizing this layout for construction purposes and reducing the cost of temporary trackage. Future conditions might make it desirable to receive coal by barge, in which case there is ample room to install a tower and unloading equipment.

When the coal is received at the station from either storage or railroad, it is dumped into track hoppers covered by a low house. There will be two hoppers in the ultimate design, accommodating four cars at a time. Underneath each hopper is an apron conveyor 60 in. wide which receives the coal and conveys it to two 36 x 48-in. double-roll crushers of 130 tons per hour each; chutes and bypasses allow either conveyor to discharge to either crusher.

From the crushers the coal passes to two pivoted-bucket elevator conveyors with 30 x 36-in. malleable-iron buckets, and is delivered to the central bunker. Each elevator has a capacity of 130 tons an hour, at a speed of 45 ft. per min.

All drives, on the coal-handling equipment, are by induction motors, the controls of which are interlocked so that starting and stopping the various apparatus can be done only in the proper sequence. Only one hopper, feeder, crusher and elevator are included with the first installation.

Ashes are dumped from the stoker into brick-lined concrete hoppers of capacity for a 24-hour accumulation. In the bottom of each hopper are four 36 x 48-in. air-operated ash gates through which the ashes are dumped into standard-gage railroad cars and taken away.

In the present installation the four boilers are of the Bigelow-Hornsby Co. water-tube type, each one has an integral economizer of approximately 20 per cent of the boiler-heating surface, and they are placed in the rear part of the boiler settings. The steam pressure

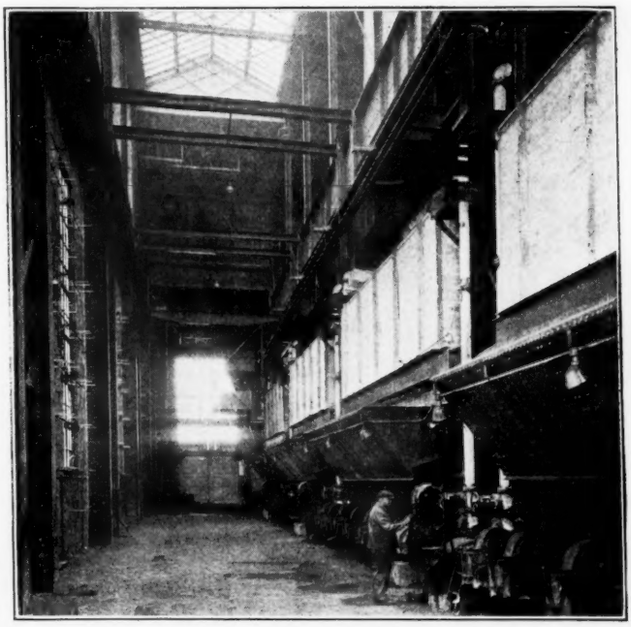

FIG. 3. CLEAR SPACE OVER FIRING AISLE FOR LIGHT AND VENTILATION IN BOILER ROOM

in the boilers is 275 lb. gage. Each boiler has a 6,250-sq.ft. superheater, designed to give 225 deg. F. superheat at 200 per cent boiler rating, making a total steam temperature of 640 deg. F.

Stokers of the Riley underfeed, multi-retort, extra-

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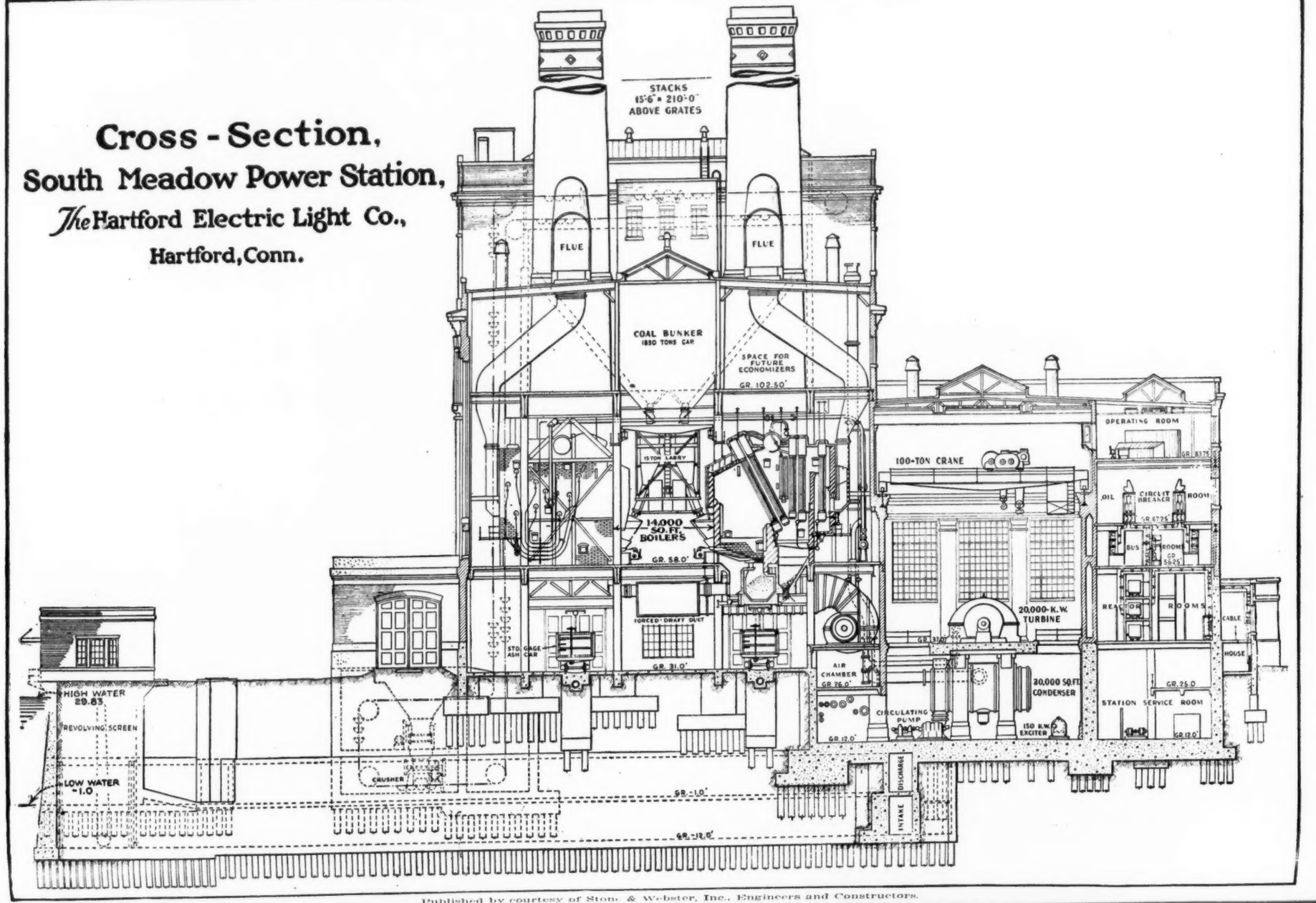

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long type with continuous dump plates, are used. Each stoker has 16 retorts with 286 sq.ft. of projected grate area. The furnace volume is liberal, being 6,370 cu.ft., or 22.2 cu.ft. per square foot of grate surface.

In general the boiler settings are of first- and second-quality firebrick with common brick used only on the outside of economizer walls. A steel wainscot about six feet high has been placed around the side walls to protect the brickwork. Furnace sidewalls have the Bernitz system of ventilation to prevent clinker formation, and the bridge walls have a facing 24 in. high of carborundum brick, opposite the dump plates to resist abrasive action of clinkers.

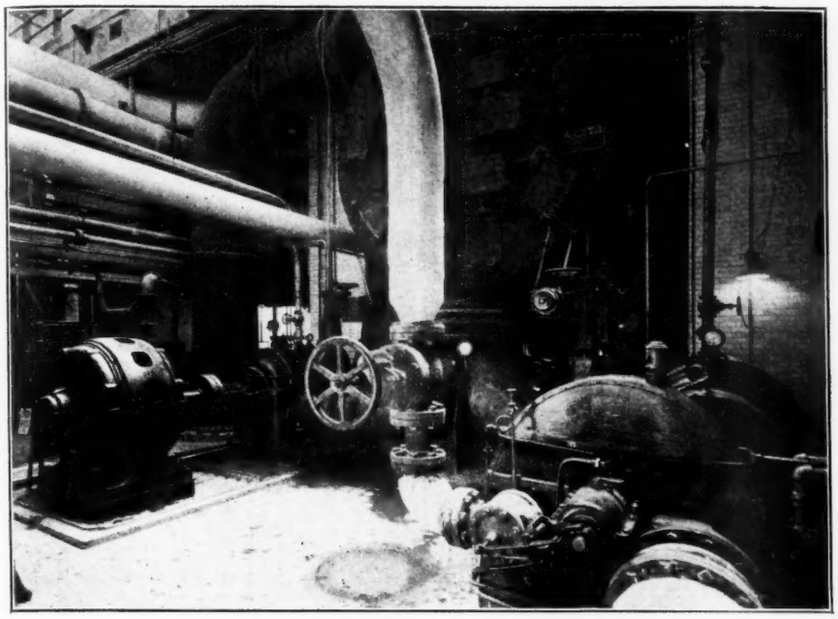

FIG. 5. CONDENSER PIPING AND CIRCULATING-WATER PUMPS

Each stoker has a geared steam-turbine drive on one end and a four-speed induction motor on the other end. The turbine is equipped with automatic regulation, by which the speed can be varied with the steam demand. The motor is four-speed hand control which, in conjunction with the gears on the stoker, gives six different operating speeds.

Air for combustion is supplied by forced-draft fans of 200,000 cu.ft. per min. capacity, two at present installed and six in the ultimate installation. The fans are of the turbo-vane type, driven through gears by steam turbines, and are located in the forced-draft supply chamber. Their turbine drives are on the other side of a partition wall in a recess of the turbine room. The air supply is drawn from the boiler room and outdoors. Each fan discharges into a common duct placed under the floor of the boiler aisle. Dampers are placed at each fan, in each stoker wind-box connection and in the main duct at every fourth boiler.

The stack is of concrete, 15 ft. 6 in. x 215 ft. above grates and superimposed on steel. One stack serves four boilers. The horizontal flues are on the roof and are not insulated. Space is provided for the installation of separate economizers and induced-draft fans should conditions warrant their installation at any future time.

A room has been provided in the center of the ultimate plant in which have been installed the instruments and equipment for the regulation of the operation of boiler-room apparatus and the control of the station heat balance. This arrangement brings the various phases of the plant operation under the observation of one man and enables him to maintain the proper heat balance at all times. In addition to the instruments in the control room there are pressure and draft gages and flow meters located at each boiler, so that individual as well as plant operation can be checked.

In the immediate installation there are two 20,000-kw. General Electric turbo-generators having 23-stage turbines, which have a water rate of 10.1 lb. at their most economical load. They are supported on reinforced-concrete foundations of considerable mass and insulated from the building structure. Under each turbine there is a 30,000-sq.ft. Westinghouse surface condenser bolted directly to the turbine exhaust nozzle and supported on springs. These springs were carefully calibrated and adjusted in the usual manner for weight of condenser light, loaded and expansion increment. Condenser auxiliaries have been provided in duplicate. There are two 18,000-gal.-per-min. circulating-water pumps with bottom suction and motor-operated valves on the discharge. One pump is

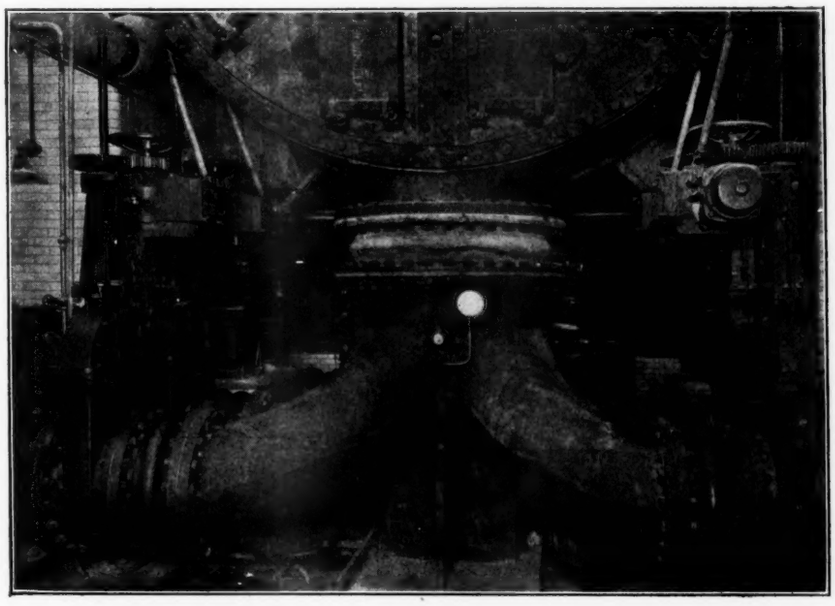

FIG. 6. CONNECTION BETWEEN CONDENSER AND CIRCULATING PUMPS

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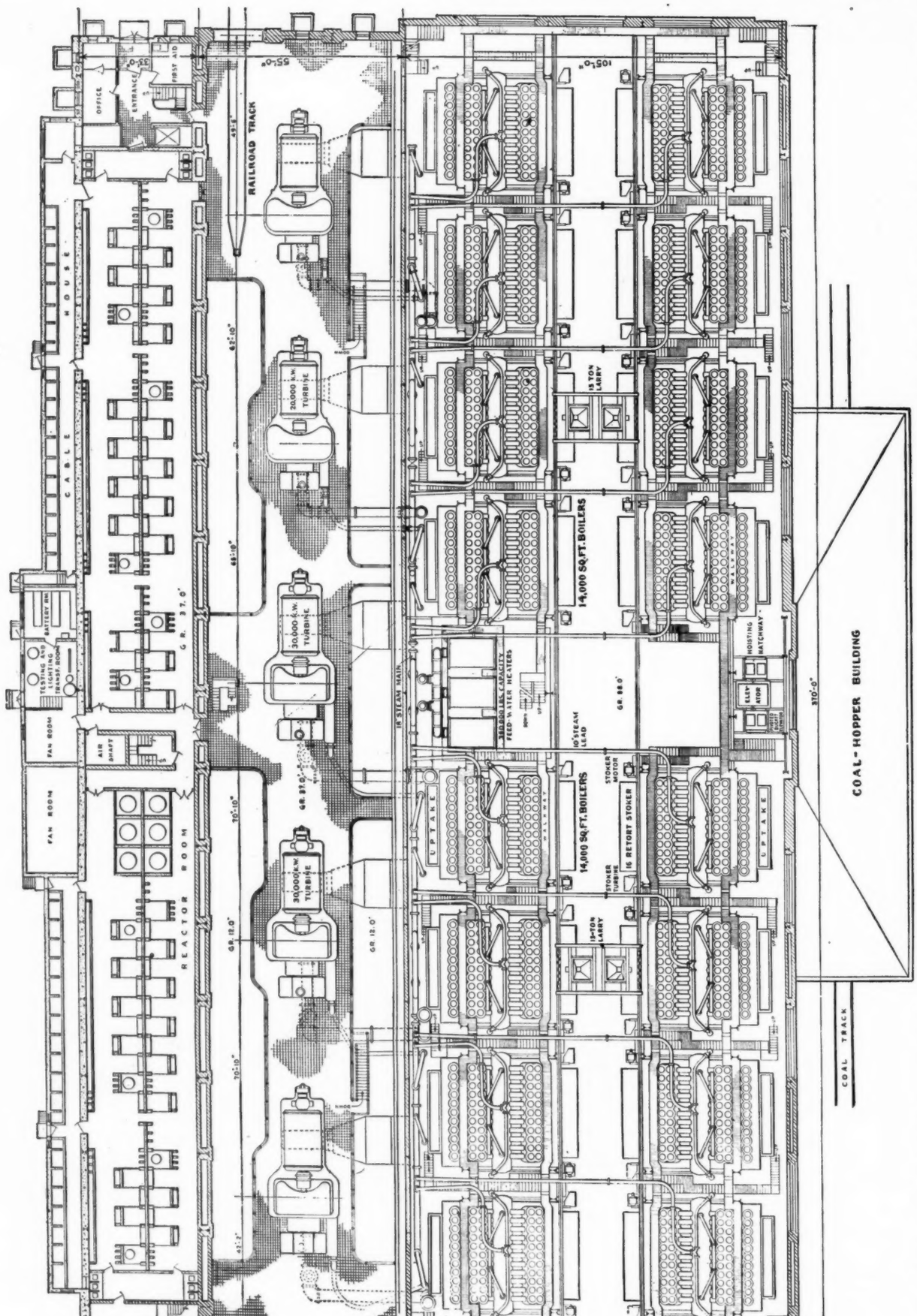


FIG. 7. PLAN VIEW OF STATION WHEN COMPLETED, SHOWING ARRANGEMENT OF TURBINES AND BOILERS. COAL BUNKER LOCATED OVERHEAD IN THE CENTER OF ULTIMATE BOILER PLANT, AND TRAVELING LARRIES SERVE THE BOILERS

driven through gears by a steam turbine, and the other is direct-connected to an induction motor. One pump is capable of producing an economical vacuum during most of the year. One condensate pump is direct-connected to a steam turbine and the other to an induction motor. Each is capable of carrying the entire load. There is one Le Blanc hydraulic air pump driven through gears by a steam turbine and one two-jet single-stage air exhauster discharging into a small surface condenser supplied with condensate or service water. The hydraulic pump is used for normal operation.

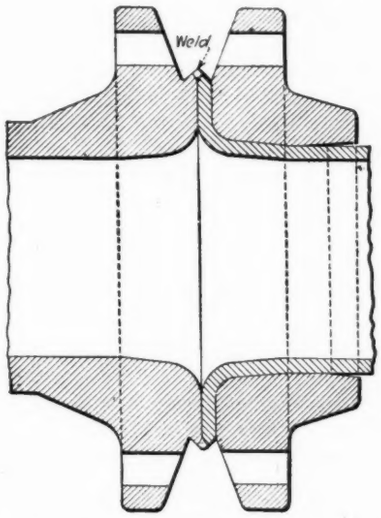


FIG. 8. JOINTS BETWEEN SECTIONS OF MAIN STEAM LINE ARE BOLTED AND THEN WELDED

The choice of auxiliaries in service is governed by operating conditions and heat-balance requirements, the intent being to maintain the feed-water temperature between 180 and 212 deg. F. In case operating conditions at light loads should occasion a choice of auxiliaries that would give some excess steam, this would automatically be bled into a main unit. The choice of auxiliaries and provision for heat balance was largely governed by the fact that one 20,000-kw. unit was to be installed as the first step, a similar unit a year later, and the balance as load conditions require. The comparatively small initial installation and the uncertain rate of load growth eliminated consideration of a house turbine due to the higher initial investment required.

The feed-water heaters, tanks and pumps are under the coal bunker and centrally located as regards the ultimate development. No purification system is contemplated at present as the river water is good for boiler use. There is space, however, for an evaporation system for the makeup if future operation shows it to be necessary.

No system for removing air and other gases from the feed water has been installed at present, other than deactivating material placed in the feed-water heaters. Space is provided, however, for the installation of air-removal equipment. The insides of the economizer tubes and drums have been painted with a special rust-resisting compound. It is proposed to keep the temperature of the feed water entering the steel-tube integral economizers above 180 deg. F., and their condition will be carefully watched during the early periods of operation.

In operation, the condensate pumps discharge into a 5,000-gal. overhead surge tank, the water first passing through the turbine oil coolers and, if in operation, the condensers for the steam air jets. The clean returns from bearings, etc., are also discharged into the same tanks. Makeup water is added by float control from the service tank overhead. The water flows from the surge tank to the heaters under float control and to the boiler-feed pumps under an 80-ft. head. The boiler-feed system consists of a main and auxiliary header with connections to each feed pump. Each boiler has two 4-in. connections with a venturi meter and a feed-water regulator in each.

The 20,000-gal. service tank is of novel design in that it has a partition which separates power service from house service. The power-service side contains filtered water and the house-service unfiltered water. The overflow is on the house-service side, and the arrangement of floats on the water supplies permits the filtered water to flow over the partition if necessary, but not the reverse. This eliminates the possibility of unusual house-service requirements interfering with continuity of power-service requirements. Both surge and service tanks have electrical indicators which show

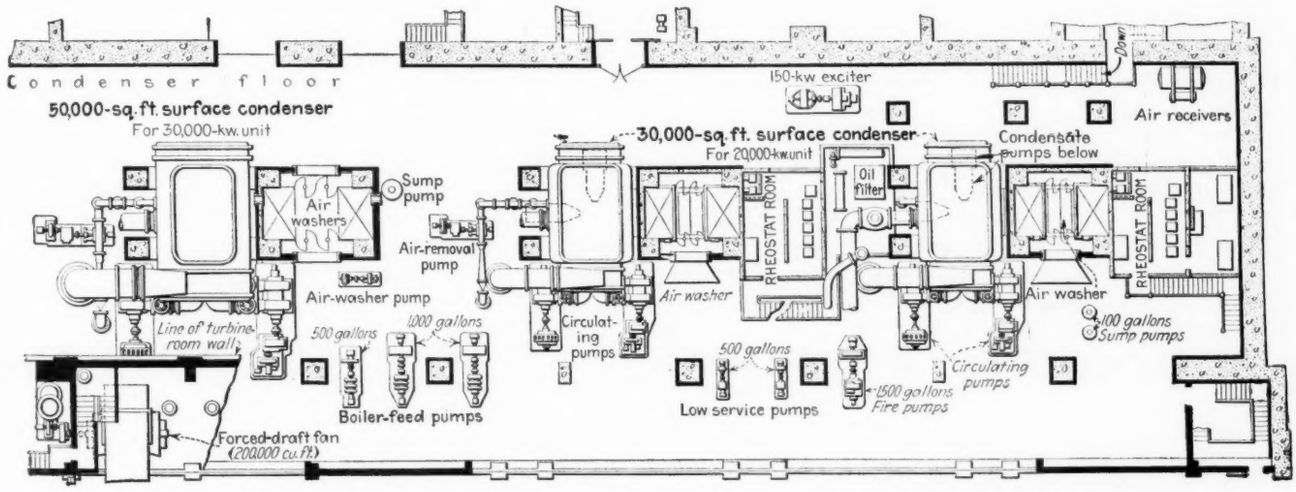


FIG. 9. ALL AUXILIARY EQUIPMENT IS LOCATED ON BOILER-ROOM SIDE OF MAIN UNITS

in the turbine room the level of the water in the tanks. Clean and dirty water sumps, with motor-driven float-controlled centrifugal pumps, permit all clean water being returned to the system and dirty water thrown away.

All piping has been laid out with a view toward securing maximum simplicity with the minimum amount of duplication necessary for continuity of operation.

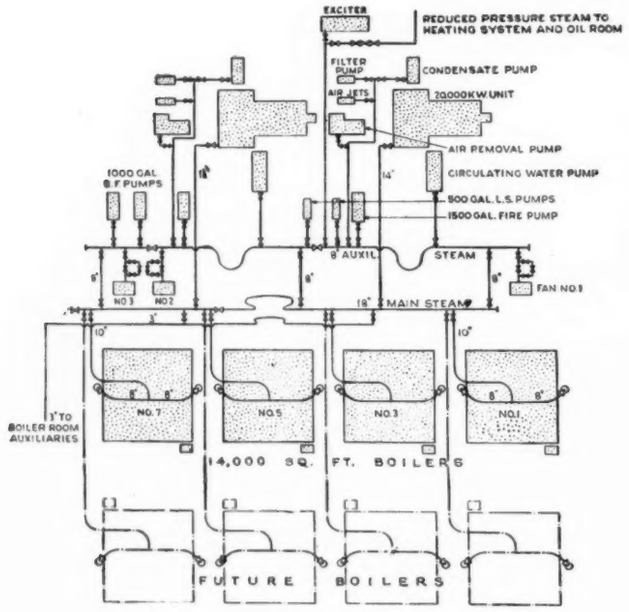


FIG. 10. DIAGRAM OF STEAM LINES

All steam-driven units are on the side of the turbine room nearest the boiler room with the consequent minimum length of runs. All headers are arranged symmetrically and with ample room for maintenance and access.

The main high-pressure steam piping has cast-steel

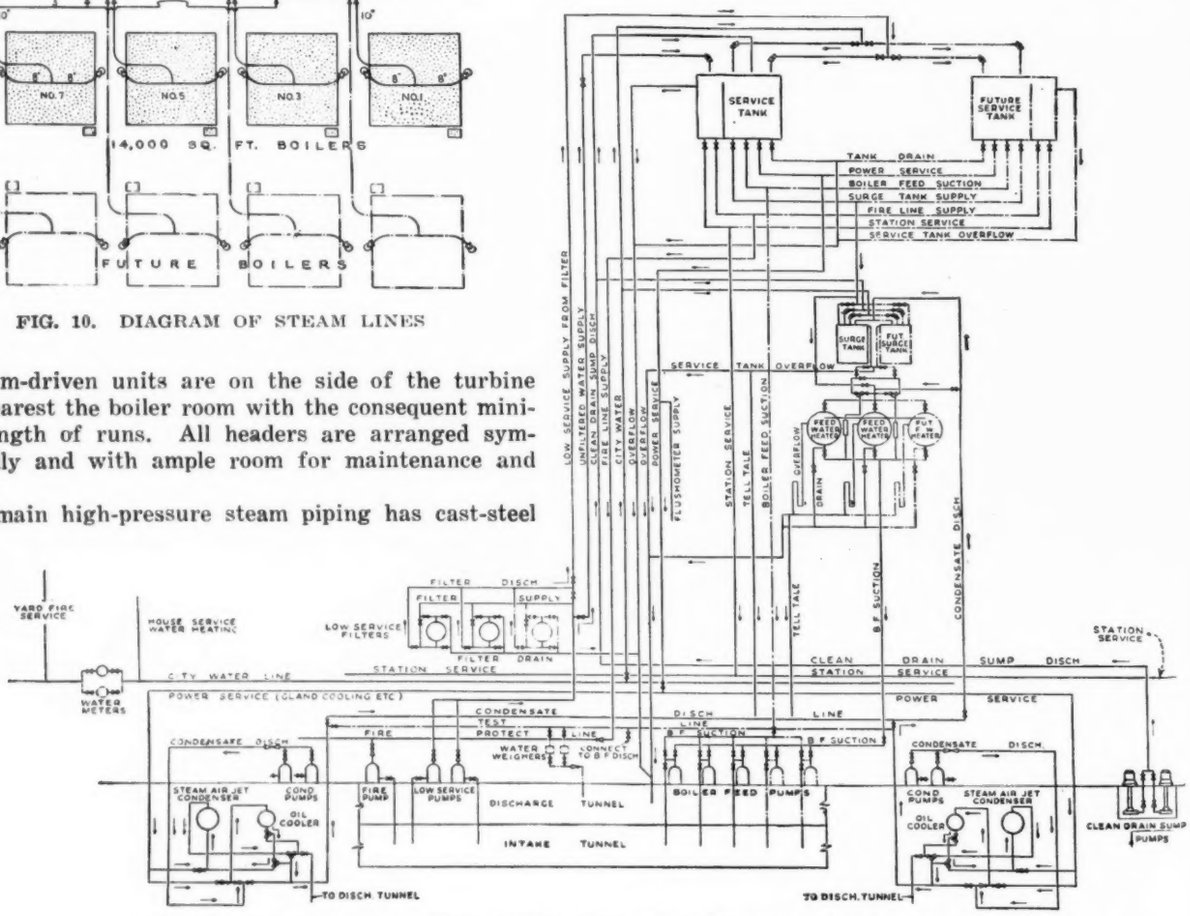


FIG. 11. DIAGRAM OF WATER LINES, WITH SERVICE AND SURGE TANKS

fittings and valves, rolled-steel Van Stone flanges on the pipe and with all flanges of the "Sargol" welded type. Joints between sections are bolted and then welded as in Fig. 8. Welded nozzles of the interlocking type and line welds of the telescope type have been used to decrease the number of joints. Each boiler has two 8-in. outlets, one on each side, connecting into a 10-in. line leading to the main header. This header is 18 in. outside diameter placed about four feet above the boiler-room floor and sectionalized with valves between every four boilers. The turbine leads are 14 in. outside diameter taken off the top of the header, one in each section, and are well drained and flexible.

Each main-turbine steam lead is provided with a motor-operated valve at the point where it leaves the main steam header. The valve is arranged so that it must be opened by hand, but may be closed by the motor, and a control switch for this purpose is placed adjacent to the valves. A second closing-control device is located in the main switchboard operating room so that in case of emergency the machine may be shut down by the switchboard operator.

The auxiliary steam header is 8 in. diameter and located in the turbine room under the forced-draft air chamber. This space forms a pipe bay easy of access. The header is sectionalized by valves, one section for auxiliaries to each main unit and with the supply connections from the main header feeding each section. Auxiliaries for general service such as boiler-feed pumps are arranged so that they are not all connected to the same section, permitting any section of the auxiliary header being cut out without interfering with continuity of plant operation.

The auxiliary exhaust consists of a single header with 20-in. riser to the heater. The extension of the station contemplates a separate header with another 20-in. riser. The larger sizes of exhaust piping are made with Van Stone flanges.

Considerable complexity of piping has been eliminated by designing in advance of construction some of the

smaller piping systems. Such, for example, is the system of air exhausting for priming pumps. This consists of two 3-in. exhausters for each main unit, conveniently located, and with air piping only run to each pump to be primed. The pumps are also primed quickly and with a minimum of operating attendance.

The Holly system has been used for high-pressure drips, with the addition of a flooding receiver and trap placed under the usual Holly receiver, so that instead of unusual quantities of water flooding the Holly system, it would overflow and be automatically returned to the feed-water heaters.

The circulating-water tunnel system in the immediate installation has capacity for 70,000 kw. The screenhouse has the usual arrangement of traveling screens, gates and racks. Inside the building the discharge tunnel is located over the intake tunnel with wells at each turbine. As the plant is increased in size, these tunnels will be extended and an additional screenhouse and intake branch constructed to give the required capacity.

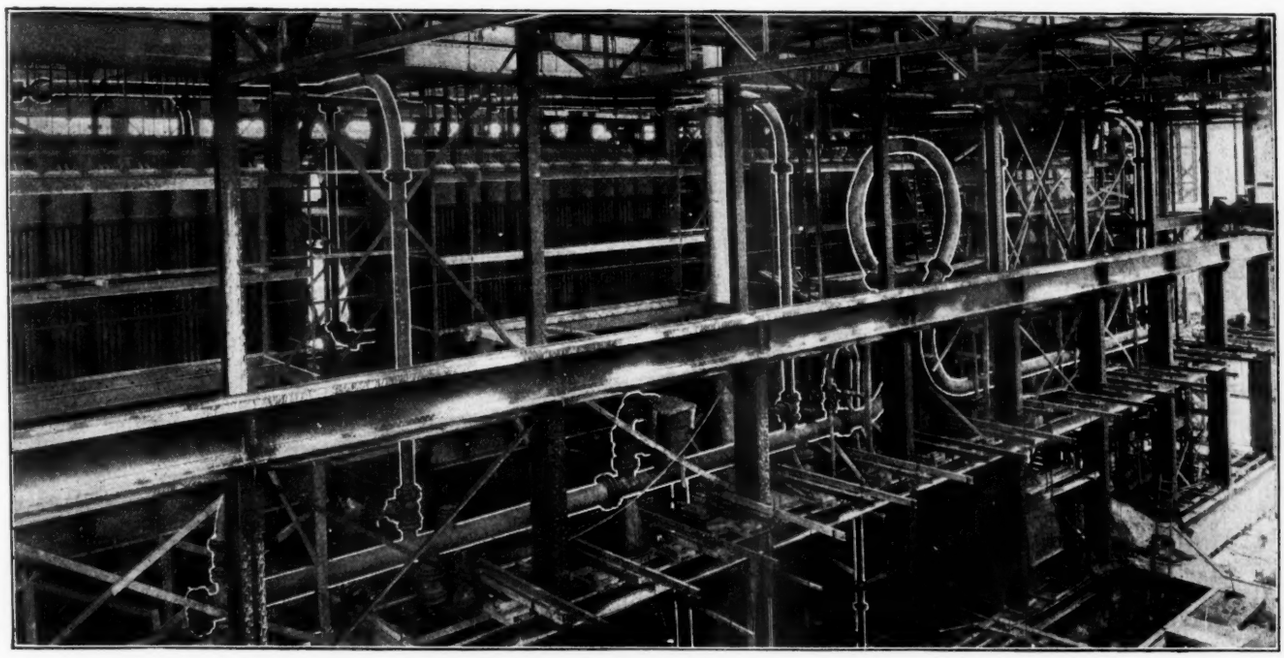


FIG. 12. MAIN STEAM HEADER BACK OF BOILERS DURING CONSTRUCTION

The main generators are three-phase, 60-cycle 11,000-volt units, and each has a direct-connected 250-volt exciter, large enough for one generator only. A separate steam-turbine-driven exciter is provided as a relay, the capacity being sufficient to excite the largest unit that will be installed in the station. Provision is made for the future installation of a duplicate steam-driven exciter. Normally, there will be no parallel operation of exciter units, but exciter connections may be transferred without interrupting excitation service. Generator- and exciter-field rheostats and switches are electrically operated and located on a gallery directly under the turbine platform at the end of each generator foundation.

The neutral of each generator is connected through an oil circuit breaker to the neutral bus, which in turn is connected to ground through a resistance of 5 ohms having a carrying capacity of 1,300 amperes for one minute. Provision is made for short-circuiting this resistance in case it is necessary to furnish sufficient current to burn out a grounded cable. Normally, only one generating unit will be connected to the ground bus.

Each generator circuit is protected by differential relays operated from current transformers located at both ends of each phase winding. These relays trip the two main oil circuit breakers, the neutral oil circuit breaker, the generator-field switch and the turbine throttle.

An interesting feature of this installation is the closed system of generator air cooling. For each 20,000-kw. unit, 55,000 cu.ft. of air per minute is required for generator cooling. This is continuously recirculated in a closed chamber and cooled after each passage through the generator by means of water sprays, Fig. 13. The distance between the turbine sub-base and the condenser floor is 25 ft. There was, therefore, ample space for the whole equipment under the generator end of the turbine foundation. The enclosure is built of brick and concrete to eliminate noise, and the arrangement provides for two sets of sprays, on in the uptake to each end of the generator. This arrangement gave greater space with consequently lower air velocity and also permitted using an arrangement of dampers whereby air can, if occasion requires, be drawn from the turbine room and discharged back into the room or into the suction chamber of the forced-draft fans. This arrangement permits, during the winter, using generator air to assist in heating the turbine room and reduce roof condensation by throwing down the excess moisture as the air passes through the sprays. In addition to this there will be introduced into the room about 20,000 cu.ft. per min. of heated outside air so as to maintain a slight positive pressure in the room. The dampers are interlocked by means of gears and operated by an electric motor for quick change from closed system to open system in case of loss of water pressure. River water, supplied by a motor-driven pump is normally used for cooling.

An emergency-service water connection is also provided, arranged to come automatically into operation from loss of water pressure.

The use of the closed system of generator cooling greatly reduces the risk of fires occurring in the unit, as the deposit of dust and dirt contained in the air drawn from the room or outside is practically eliminated, and in addition it limits the amount of air necessary to support combustion. It also makes it possible to substitute, for the usual water or steam sprays, a system of gas smothering to put out generator fires. After considerable investigation carbon dioxide in gaseous form was selected as the smothering agent. This will be purchased in containers at approximately 2,000-lb. pressure and admitted into a steel tank where the gas will be stored at 200-lb. The gas is piped to each generator with the necessary valves, drains and steam-jacketed nozzles and will be admitted into the inclosed space at a point just under the air inlets to the generators. Small relief dampers are provided, opening into the duct leading to the forced-draft fans, and will be opened by the increase in pressure in the inclosure due to the admission of CO_2. This flushes out the air and later, when the pressure in the inclosure decreases due to the admission of CO_2 stopping, the reliefs close. Tests on this fire-extinguishing equipment have not yet been made, so that actual operating results are not available.

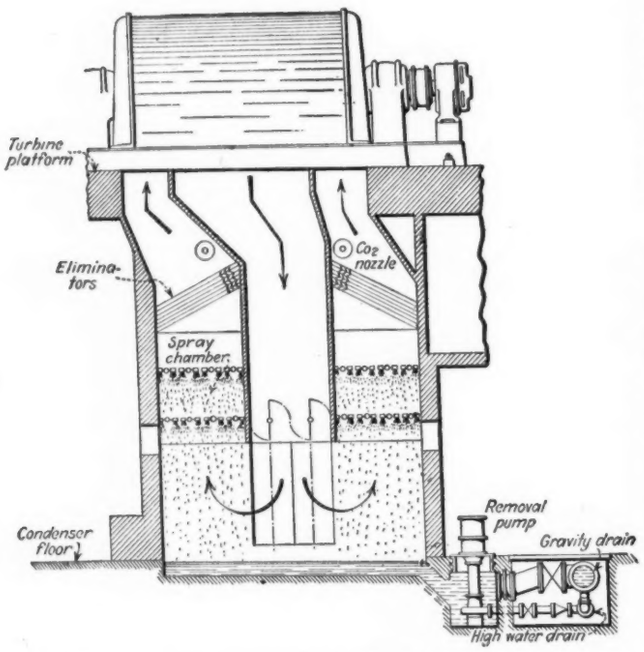


FIG. 13. SECTION THROUGH GENERATOR AIR-WASHING AND VENTILATING SYSTEM

Ultimately, there will be three banks of station power transformers, any two of which will be sufficient to carry all station auxiliaries, each bank consisting of three 1,000-kva. single-phase self-cooled 11,000- to 2,300-volt transformers connected delta to delta. At the present time only four of these transformers are installed, connected in two open-delta banks, either bank being sufficient to care for the existing equipment. In general, motors of 50 hp. and larger are operated on 2,300 volts, smaller motors being operated at 220 volts and supplied from auxiliary 220-volt transformer banks.

The station transformers are located out of doors alongside the electrical bay at about the center of the ultimate building. The control of the 11,000-volt side of these transformers is placed on the main 11,000-volt switchboard, the secondaries being controlled from a truck-type switchboard underneath the electrical bay in a room on a level with an opening from the condenser floor. The truck-type switchboard controls all 2,300-volt auxiliary circuits, and since these circuits are operated almost entirely by men not especially familiar with electrical equipment, this type of panel seems particularly adapted to the purpose. A second auxiliary-power room is provided in the basement of the boiler house, and in this room is located a bank of three 150-kva. 2,300-220-volt transformers with the necessary control panels for supplying energy to 220-volt motors in the boiler house.

A signal pedestal is located in the main control room, from which the usual operating signals can be sent to miniature signs on each turbine-room gageboard. On this pedestal are two miniature signs, one of which shows the signal being sent, while the other shows the return signal for checking. This pedestal also mounts the control for the two load bulletin boards—one of which is on one end wall of the turbine room and the other in the firing aisle in the boiler house. The control for the emergency whistles is also on this pedestal. All circuit break bell alarm, tranformer temperature alarm and similar signal circuits are connected to an annunciator board located on the operator's desk.

Particular attention has been given to the question of lighting, and upon entering, one is struck with the abundance of natural light in practically every portion of the station. Ample skylights are provided over the boiler aisle, the turbine room and in the switchboard-operating and load-dispatching rooms. The central arrangement of the coal bunker and the limiting of the turbine-room floor to a turbine platform permits a flood of natural light to reach the boiler-room floor and the condenser floor. The turbine-room walls are lined with enameled brick, which adds materially to the natural illumination. At night ample general illumination is provided in the boiler room and in the turbine room.

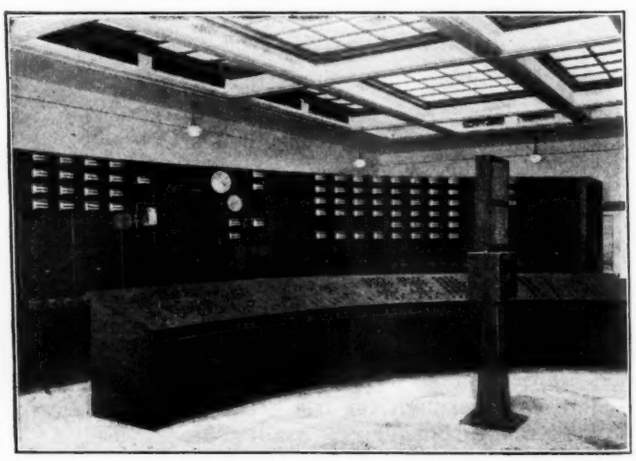


FIG. 14. MAIN SWITCHBOARD IN CONTROL ROOM

Power wishes to acknowledge the assistance and cooperation rendered in the preparation of this article by the engineers of Stone & Webster, Inc., and the officers of the Hartford Electric Light Company.

DATA ON PRINCIPAL EQUIPMENT IN THE SOUTH MEADOW STATION OF THE HARTFORD ELECTRIC LIGHT COMPANY

GENERAL

Location of plant	Hartford, Conn.
Character of load	Light and power
Capacity, ultimate	130,000 kw.
Capacity, present, two 20,000-kw. units	40,000 kw.
Boilers, ultimate (14,000 sq.ft. each)	16
Boilers, immediate	4
Turbine room, ultimate	362x55 ft.
Turbine room, immediate (3 units)	203x55 ft.
Electrical bay, ultimate	358x33 ft.
Electrical bay, immediate	201x33 ft.
Boiler room, ultimate	370x105 ft.
Boiler room, present	205x67 ft.
Coal-bunker building	105x42 ft.
Distance from condenser floor to turbine platform	25 ft.
Distance from ashroom floor to boiler-operating floor	27 ft.

BOILERS AND SUPERHEATERS

Make of boilers	Bigelow-Hornsby
Type	Water-tube
Number, ultimate	16
Number, installed	4
Width of firing aisle	26 ft.
Water-heating surface per boiler	13,920 sq.ft.
Grate area projected per boiler	286 sq.ft.
Ratio water-heating surface to grate area	49 to 1
Heating surface per kilowatt installed, ultimate	1.7 to 1
Heating surface per sq.ft. boiler-room floor area, ultimate	5.7 to 1
Furnace volume	6,370 cu.ft.
Ratio furnace volume to water-heating surface	1:2.2
Ratio furnace volume to projected grate area	22.2 : 1
Size of tubes	3½ in., No. 9 B.w.g.
Boiler pressure, gage	275 lb.
Type of superheater	Foster
Manufacturer	Power Specialty Co.
Location of superheater	Between first and second nest of tubes
Superheating surface	6,250 sq.ft.
Ratio superheating to boiler-heating surface	1 to 2.2
Superheat at 200 per cent rating	225 deg. F.
Total steam temp., at 200 per cent rating	640 deg. F.
Type of setting	Solid firebrick
Kind of fuel	Coal
Heat value of fuel (dry)	14,000 B.t.u.
Proximate analysis	Ash 8%, moisture 4%, volatile 25%, fixed carbon 63%

STOKERS

Manufacturer	Sanford Riley Stoker Co.
Type	Underfeed, extra long
Number of retorts	16
Drive	Motor and turbine
Manufacturer of turbine	Terry Steam Turbine Co.
Manufacturer of motor	General Electric Co.
Stoker performance	77% efficiency at 200% rating

Rating per Cent	Cu.Ft. Air per Min.	Lb. Coal per Sq.Ft. Grate per Hour
200	23,000	31

ECONOMIZERS

Make	Bigelow-Hornsby
Location	Integral, in rear of boiler setting
Heating surface	2,750 sq.ft. each
Sq.ft. economizer surface per sq.ft. boiler-heating surface	0.2

CHIMNEYS

Type	Concrete
Manufacturer	Heine Chimney Co.
Height above grate	215 ft.
Inside diameter at top	15 ft. 6 in.
How supported	Superimposed on building steel structure

COAL HANDLING

Type	Pivoted bucket
Furnished by	Stephens-Adamson Mfg. Co.
Capacity (present)	130 tons per hour
Drive	Motor
Storage capacity (present total)	About 15,000 tons
Additional storage at present	Dutch Point Station
Bunkers (kind and size)	Concrete, 2,000 tons
Method of reclaiming from storage	Locomotive crane and railroad cars
Coal weighing	Larry scales

PRIME MOVER

Type	Turbine
Manufacturer	General Electric Co.
Number, ultimate	5 (2—20,000 kw., 3—30,000 kw.)
Capacity, rated	40,000 kw. immediate—130,000 kw. future
Capacity per sq.ft. turbine-floor area (complete plant)	$\frac{130{,}000}{362 \times 55} = 6.5$
Number of stages	23
Speed	1,800 r.p.m.
Weight per kilowatt	21.8 lb.
Pressure at throttle, gage	250 lb.
Temperature at throttle	631 deg. F.
Guaranteed performance	10.10 lb. at 14,000 kw. and 29-in. vacuum
Type of generator	Three-phase, 11,000 volts
Manufacturer	General Electric Co.
Ventilation of generators (air)	55,000 cu.ft. per min. (each)
Size of exciters	Main unit, 110 kw. (1 spare 150 kw.)
Drive for main exciters	Direct-connected to main unit
Drive for spare exciter	Turbine
Manufacturer	Terry Steam Turbine Co.
Ratio exciter capacity to generator capacity	1 to 182
System of lubrication	Partial filtration and central tanks

CONDENSERS

Type	Surface
Make	Westinghouse
Number	2
Support	Springs
Tube surface	30,000 sq.ft.
Square feet tube surface per kilowatt of prime mover	1.5
Performance	28.5 in. vacuum—210,000 lb. steam per hr.—30,000 gal. per min. at 65 deg. F.
Circulating pumps, number	2 per main unit
Make	Westinghouse
Drive	1 motor, 1 turbine
Capacity	18,000 gal. per min. each
Capacity per kilowatt installed	1.8 gal. per min.
Intake cross-section per 1,000 gal. circ. water per min	1.5 sq.ft.
Condensate pumps, number	2 per main unit
Manufacturer	Worthington Pump & Mach. Corp
Capacity, each	450 gal. per min.
Drive	1 motor, 1 turbine
Make	Westinghouse
Air pumps	2 per unit
Type	1 LeBlanc, hydraulic, 1 two-jet single-stage steam jets
Make	Westinghouse
Type of screens	Traveling
Manufacturer	Link Belt Co.
Drive	Motor
Travel of screens	15 ft. per min.

MISCELLANEOUS EQUIPMENT

No.	Equipment	Type	Size	Manufacturer
2	Forced-draft fans	Turbo-vane	200,000 cu.ft. per min	B. F. Sturtevant Co.
2	Forced-draft fan turbines	Geared		Westinghouse Elec. & Mfg. Co.
2	Feed-water heaters	Open-Cochrane	540,000-lb. per hr.	H.S.B.W. Cochrane Corp.
4	Soot blowers	Diamond	20 units	Diamond Power Spec. Co.
1	Coal-storage crane	Locomotive	20-ton, 50-ft. boom	Ohio Locomotive Crane Co.
1	Coal conveyor	Apron	60-in	Stephens-Adamson Mfg. Co.
1	Coal crusher	Double roll	130 tons per hr.	
1	Coal conveyor	Pivoted bucket	30x36 in	
1	Coal larry	Weighing	15-ton	McCarthy Bros. & Ford
2	Air conditioning	Water sprays—closed system	60,000 cu.ft. per min	Carrier Eng. Corp.
2	Air-washer supply pumps	Horizontal, driven by induc. motor	500 gal. per min.	Worthington Pump & Mach. Corp.
2	Air-washer discharge pumps	Vertical, driven by induc. motor	500 gal. per min.	Worthington Pump & Mach. Corp.
2	Boiler-feed pumps	3-stage Jeanesville, driven by steam turbine	1,000 gal. per min.	Worthington Pump & Mach. Corp.; Terry Steam Turbine Co.
1	Boiler-feed pumps	4-stage Jeanesville, driven by steam turbine	500 gal. per min.	Worthington Pump & Mach. Corp.; Terry Steam Turbine Co.
2	Service pumps	Single-stage driven by st. turbine	500 gal. per min.	Worthington Pump & Mach. Corp.; Terry Steam Turbine Co.
1	Fire pump	2-stage driven by st. turbine	1,500 gal. per min.	Worthington Pump & Mach. Corp.; Terry Steam Turbine Co.
2	Clean-drip pumps	Vertical, motor-driven	300 gal. per min.	Worthington Pump & Mach Corp.
2	Dirty-drip pumps	Vertical, motor-driven	100 gal. per min.	Worthington Pump & Mach. Corp.
2	Water filters	Sand-pressure type	250 gal. per min.	International Filter Co.
2	Intake-well pumps	Vertical, motor-driven	900 gal. per min.	Worthington Pump & Mach. Corp.
1	Station crane	Electric bridge	5 motor, 100 ton	Northern Engineering Works

MISCELLANEOUS METERS, VALVES, PIPING, ETC.

Equipment	Manufacturer
Stets feed-water regulators	The Williams Gage Co.
Boiler-damper control	The Engineer Co.
Safety valves	Consolidated Safety Valve Co.
Blow-off valves	Yarnall Waring Co.
Blow-off valves	Everlasting Valve Co.
Furnace side-wall ventilation	Bernitz Furnace Appliance Co
Adamant fire cement	Botfield Refractories Co.
Carborundum brick and cement	The Carborundum Co.
Firebrick and clay	Queens Run Fire Brick Co.
Sil-O-Cel blocks	Celite Products Co.
Apexior boiler paint	The Dampney Co. of America
Smoke flues and air ducts	The Porcupine Co.
Forced-draft fan and stoker controllers	The Hagan Corp.
Surge and storage tanks	The Porcupine Co.
Muntz-metal condenser tubes	Chase Metal Works
Intake sluice gates and hoists	S. Morgan Smith Co.
Circulating-water valves	Pratt & Cady Co., Inc.
Rubber expansion joints	Westinghouse Elec. & Mfg. Co.
Copper expansion joints	E. B. Badger & Sons Co.

DATA ON PRINCIPAL EQUIPMENT IN THE SOUTH MEADOW STATION OF THE HARTFORD ELECTRIC LIGHT COMPANY (CONCLUDED)

Condenser-supporting springs	Fort Pitt Spring & Mach. Co.
Ash gates	Baker-Dunbar-Allen Sales Co.
Atmospheric-relief valves	Edward Valve & Mfg. Co.
Boiler stop and check valves	Edward Valve & Mfg. Co.
High-pressure steam globe and angle valves	Edward Valve & Mfg. Co.
High-pressure water globe and angle valves	Edward Valve & Mfg. Co.
Sargol welded joints	Edward Valve & Mfg. Co.
High-pressure steam-gate valves	Pittsburgh Valve, Foundry & Const. Co.
High-pressure steam pipe and fittings	Pittsburgh Valve, Foundry & Const. Co.
Low pressure steam and water fittings	Pittsburgh Valve, Foundry & Const. Co.
Large main exhaust castings	Pittsburgh Valve, Foundry & Const. Co.
Holly high-pressure drip system	Russell B. Hobson
Low-pressure steam and water valves	Pratt & Cady Co., Inc.
Atmospheric-exhaust piping	Abendroth & Root Co.
High-pressure semi-steel pipe and fittings	The Lumsden & Van Stone Co.
Cast-iron circulating-water pipe and fittings	The Lumsden & Van Stone Co.
Miscellaneous cast-iron pipe and fittings	Pittsburgh Piping & Equipment Co.
Venturi meters	Simplex Valve & Meter Co.
Continuous turbine-oil filtration	Richardson-Phenix Co.
Refrigerating machinery	Automatic Refrigerating Co.
Pipe covering	Collins-Lotz Co.
Ventilating sheet-metal work	Delbrook Ventilating Co., Inc.
Steam-flow meters	General Electric Co.
Recording instruments	Foxboro Co., Inc.
Indicating gages	Star Brass Mfg. Co.
Indicating thermometers	C. J. Tagliabus Mfg. Co.
CO_2 recorders	Uehling Instrument Co.
Master steam gage	Ashton Valve Co.
Draft gages	Precision Instrument Co.
Stoker-speed tachometer	Brown Instrument Co.
Heating return valves	Warren Webster Co.
Deactivating material	Anti-Corrosion Eng. Co., Inc.

Station service transformers, protective reactors, ground resistors, switching equipment, cable and bus supports, wire, cables and flood-lamp yard-lighting fixtures furnished by General Electric Co.; storage battery, Electric Storage Battery Co.; turbine signals and load bulletins, C-P Signal Co.; lighting cabinets, Benjamin Electric Mfg. Co.; Porcelain bushings, Ohio Brass Co., and Locke Insulator Mfg. Co.; interior-lighting fixtures, Pettingell-Andrews Co., Benjamin Electric Mfg. Co., Holophane Glass Co., Inc., Hart & Hegeman Mfg. Co., and National Co.; safety switches, Trumbull Electric Mfg. Co.; cast-copper terminals, Electric Power Equipment Corp.

Should Oil-Field Boilers Be Exempt?

BY R. L. HEMINGWAY*

SOME of the recent issues of *Power* have commented in various articles on the apparent tendency of certain industries to claim exemption whenever the state in which they happened to be located endeavors to enact boiler-inspection and safety laws. The specious argument has frequently been advanced that oil-field boilers are usually set up in an open plain or on a hillside far removed from the property of others, and in such location and surrounded by such circumstances, that even if they should explode the catastrophe hazard is practically nil. The greater part of this argument, at least in so far as it relates to property, is strictly accurate, but it must be remembered that all these boilers require an attendant whose life is, or at least should be, of more consideration than all the property that ever was destroyed by boiler explosions. Who is there among us that can measure the value of a human life, whether it be in the terms of money or property or any other commodity? So once more the question is presented here, "Should oil-field boilers be exempt?"

FIG. 1. GENERAL VIEW OF THE WRECKED PLANT

In California they never have been exempt since the Boiler Safety Orders went into effect on Jan. 1, 1917. Since that date California oil fields have known several explosions of more or less violent nature, but none that could begin to compare in violence with the latest demonstration of the pent-up forces of steam. The Cresceus Oil Co. was operating three boilers in a battery on a lease near Taft, California, on July 27, 1921. No. 3 boiler at that time was the only one in active service; No. 2 had been shut down for repairs, and No. 1 was being placed in commission preparatory to cutting it in on the line for some extra night work. Without warning the boiler suddenly exploded about 9:45 p.m., instantly killing J. H. Joseph, who was temporarily in charge. Fig. 1 gives some idea of the terrific violence of this explosion. Reports received up to the present time indicate that the boiler had not been cut in on the line, but was about ready for cutting in. The rupture took place along the top center line of the boiler extending along the shell up through the dome and then down along the shell again. The rear head was practically quartered (see Fig. 2), while the front head was bent over almost at a right angle along the line of the top row of tubes. This boiler had been inspected as recently as May 31, 1921, by an insurance inspector, whose report on that date does not call for any changes or repairs.

FIG. 2. EXPLODED BOILER. ALL BRACES TORE LOOSE AT BOTH ENDS AND SHELL FLATTENED. REAR HEAD IN FOUR PIECES

A brief description of the boiler follows: It was a horizontal return-tubular type, 60 in. in diameter by

*Chief Boiler Inspector California Industrial Accident Commission.

16 ft. long and approximately ten years old; the shell plate was $\frac{3}{8}$ in. stamped flange 55,000 lb. T. S. The shell was made in two pieces; that is to say, a top and a bottom half with a longitudinal double-riveted lap joint extending the full length of the boiler on each side. There was a dome attached to the shell 36 in. in diameter, having a double-riveted flange on the dome saddle and a dished head from the top of which, by means of a boiler flange, extended the steam pipe. Conforming to common oil-field practice, on the top of a short piece of pipe was mounted a tee with a side outlet, from which extended the steam main to the pumps. The top outlet of the tee was used for attaching a safety valve, which in this case was of the spring-pop type, $2\frac{1}{2}$ in. in diameter.

The report on the explosion shows that this safety valve, in addition to being badly scaled, was also without any lifting device, although the lugs for attaching this lever were provided on the valve body. The fireman stated that it had not blown for many weeks. The immediate cause of the explosion can only be surmised, as there is no possible way of ascertaining how much pressure the gage registered just prior to the explosion, and the safety valve itself was so damaged that it is impossible to ever say at what pressure it would have blown. The best information available, however, tends to prove that this safety valve was stuck so tightly to its seat that a pressure sufficient to explode the boiler was reached before the valve showed any indication of lifting (see Fig. 3). The theoretical bursting pressure of this boiler was approximately 506 lb. per sq.in. and it seems probable that at the moment of explosion the pressure of the boiler approximated to this amount. The house in which the three boilers stood was demolished, as is shown by the illustrations and boilers Nos. 2 and 3 were thrown from their settings. Fragments of the exploded boiler were found 900 ft. away, while many of the essential parts, including the gage and siphon pipe, and main stop valves were not found. Only five tubes, all loose, remained attached to the front head of the boiler; the others, together with the débris from the explosion, were scattered over an area of one-half mile square.

FIG. 3. SHOWING SCALE, CAUSED BY FOAMING ON OUTSIDE OF THE DRUM

The initial rupture seems to have occurred at the front head where the braces, supporting the segment above the tubes, were all found broken (see Fig. 2). The head was bent over, shearing the rivets in the upper portion of the head seam, and thus started a longitudinal crack at the top center line of the shell, which extended the length of the boiler, as has been previously described.

Summing up the evidence, we have: The boiler had been fired for over $3\frac{1}{2}$ hours, more than sufficient to raise full pressure; the safety valve did not blow and had not been known to blow for many weeks; the regular attendant reported that the gage showed 40 lb. for 15 minutes and so he summoned the deceased to see what was wrong; the boiler had not been cut in on the line; and the terrific violence of the explosion (it was felt for miles) shows the presence of plenty of water and extremely high pressure.

The rules of the Industrial Accident Commission had been complied with, at least in so far that the boiler had been inspected, and a certificate issued. The real reason lies in the fact that the fireman did not report that the safety valve was inoperative and failed to realize the critical danger of operating a boiler under such conditions. As long as the state permits employers to place in charge of boilers men who have not learned the essential rudiments of safe operation, just so long will there be disasters of this kind and, as in this case, children will be deprived of the bread winner and wives left widows.

It is an old stunt to fill a paper bag with water and then boil the water by means of a gas flame playing directly against the paper. At the other end of the scale of surprises is the trick where an oxy-acetylene torch is used to burn a hole through the walls of a steel tank containing water. In the case of boiler tubes and boiler shells exposed to the heat of combustion, it seems to be practically impossible to burn the metal with any combustion temperatures now in commercial use provided the plate is not of abnormal thickness and provided the water side of the tube is free from the insulating effect of a blanket of mud, scale or pocketed steam. The latter will not, of course, occur in a properly designed boiler. It would, perhaps, be of theoretical rather than practical interest to learn at what combustion temperature, for a given boiler design and with clean surfaces, an appreciable amount of burning or bulging would take place.

The suction pressure in the refrigerating plant should be carried as high as possible, keeping in mind the temperature required in the cold-storage rooms. The efficiency of the plant is enhanced as the suction pressure increases. The discharge pressure should be carried as low as possible, consequently the flow of condenser cooling water should be increased until the discharge pressure is as low as can be obtained.

Elementary Refrigeration—A Simple Explanation of How the Compression Refrigerating System Works

By G. GROW

REFRIGERATION is in its broadest sense a process of removing heat from a substance. In the action of water in a steam boiler we have, although the temperatures are high, an instance of one substance (water) absorbing heat from another substance (the burning coal). This process, while it is correctly termed a heat process, is likewise a refrigerating process, for while heat is absorbed by the water, heat is also removed from the burning coal.

A pound of water in rising in temperature one degree, absorbs one British thermal unit from the fire. Taking 32 deg. F. as a starting point, in raising the temperature of one pound of water from 32 to 212 deg. F., 180 heat units are absorbed from the fire. If the end of the boiler or vessel is open, Fig. 1, and only the pressure of the atmosphere (14.7 lb. absolute) exerted on the contents, the water will continue to absorb heat until it attains a temperature of 212 deg. If the fire continues to burn, the temperature of the water will not rise beyond 212 deg., but the water will boil away into steam. At atmospheric pressure 180 B.t.u. are absorbed in raising the temperature from 32 to 212 deg., and 970 heat units are absorbed in changing the water 212 deg. into steam at 212 deg. If the cylinder is under pressure, the water does not boil on reaching 212 deg., but at some other temperature, depending upon the pressure.

Going further, suppose the end of the vessel is closed, as in Fig. 2, and the air above the water removed with

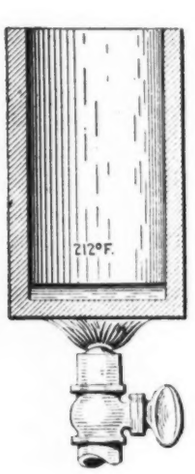


FIG. 1. BOILING WATER AT 212° F.

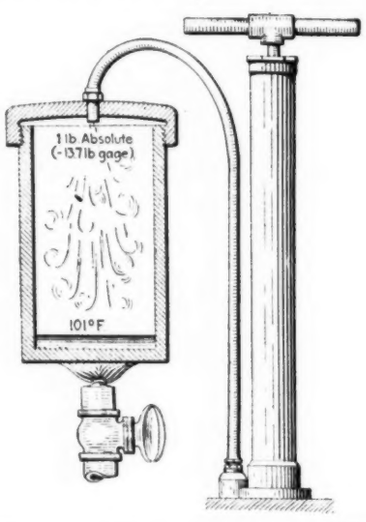


FIG. 2. BOILING WATER AT 101° F.

a hand pump until the pressure in the cylinder is 1 lb. absolute (or —13.7 lb. gage). The water now need not reach 212 deg. before boiling, but as soon as it attains a temperature of 101 deg. F., which is the boiling temperature of water at 1 lb. pressure, the water will start boiling into steam at 1 lb. pressure, provided the steam is removed as fast as formed.

Suppose the cylinder is placed in a box that is insulated to prevent loss of heat from the surroundings. The water in the cylinder is at 32 deg., and the box is filled with water at 120 deg. F. The cylinder contents will begin to absorb heat from the water in the box and will continue until both bodies of water are at the same temperature, say 101 deg., the boiling point at 1 lb. pressure. If more hot water is poured into the box,

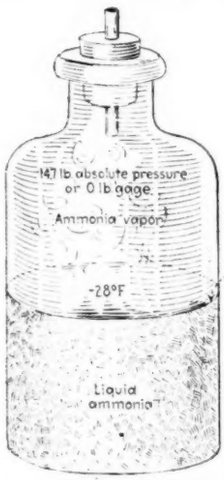


FIG. 3. BOILING AMMONIA AT ATMOSPHERIC PRESSURE

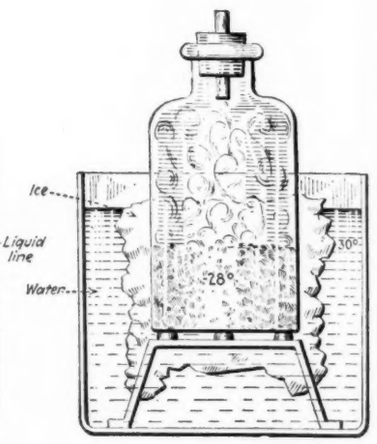


FIG. 4. FREEZING WATER WITH AMMONIA

the cylinder contents will boil away into steam. This process of absorbing heat is decidedly a refrigerating process, for we have taken water at 120 deg. and reduced it in temperature to 101 degrees.

Unfortunately, 101 deg. is entirely too high a temperature for real refrigeration, and while water will boil at 32 deg. under a pressure of 0.08 lb. absolute, it is by no means easy to secure so low a pressure. Consequently, other liquids, which will boil at 1 lb., or even greater pressure at temperatures below 32 deg., are used, such as ammonia.

Action of Ammonia

If, as in Fig 3, we have an open beaker partly filled with ammonia liquid and with the throat open to the atmosphere, the ammonia will start boiling and will drop in temperature to —28 deg. F., which is the boiling temperature of ammonia at 14.7 lb. absolute, or zero gage pressure. In absorbing heat, or boiling, the ammonia will remain at —28 deg. F. as long as any liquid ammonia remains in the beaker.

The boiling will be very rapid since the temperature of the surrounding air is much higher that the —28 deg. boiling point, and the ammonia can take up heat from the surrounding air since there is a large difference in temperature. If no breeze or air current is moving, that part of the air next to the vessel will lose much of the heat to the ammonia and consequently will drop in temperature to such an extent that any moisture in the air will be frozen and settle as frost upon the beaker, as shown in the illustrations.

If this same beaker were placed in a small tank of

water having a temperature of, say, 60 deg. (Fig. 4), the ammonia would absorb heat from the water and start boiling; the evaporation of the ammonia would chill the water and finally freeze it. This is in every respect a miniature ice plant. Such a system could work for only a few minutes because all the ammonia liquid would speedily evaporate. The beaker could be connected to a vertical tank or receiver containing a large supply of liquid, as shown in Fig. 5. The liquid will flow from the tank to the beaker as the tank is above the vessel, giving a head to offset the pipe resistance.

To prevent the liquid from flowing so fast as to fill the flask to the overflowing point, a valve or cock could be placed in the line from the receiver. As before, the ammonia liquid, being at a low pressure (0 gage), will evaporate and freeze the surrounding water. The liquid in the receiver would also evaporate since it is at atmospheric pressure, and the vapor would escape through the top of the receiver without doing any cooling of the water. If, however, we close the top of the receiver, Fig. 6, and keep the ammonia under a pressure of, say, 150 lb., the ammonia in the receiver will not boil as long as it is at a temperature lower than 70 deg. F., for ammonia under 150 lb. pressure must be heated to 70 deg. before it will boil. If this pressure is maintained, the flow of ammonia liquid through the regulating valves (so-called expansion valve) can be nicely adjusted. Such an arrangement would give almost a continuous evaporation of ammonia and freezing of ice. By regulating the escape of the ammonia vapor from the flask, any pressure desired can be maintained in the flask. If the outlet pipe of the flask is partly closed and so maintained, say 15 lb. gage (30 lb. absolute), the ammonia will evaporate at a temperature of —15 deg. F. If the amount of water surrounding the flask is controlled, it will freeze and eventually could attain a temperature of approximately —15 deg. F. if the box was completely insulated, but never below

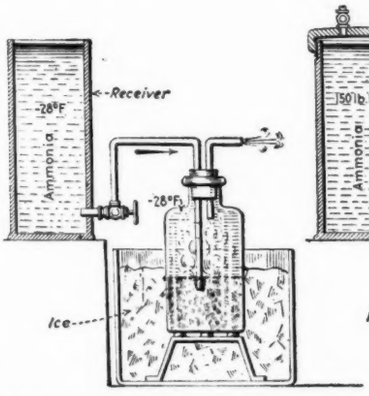


FIG. 5. AMMONIA FREEZING SYSTEM

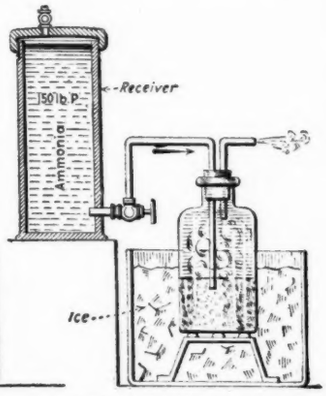


FIG. 6. MODIFICATION OF FIG. 5

this since this is the lowest at which ammonia vapor under 15 lb. gage pressure will boil. If, however, the temperature of the water was too high or the amount of water too great, the ammonia in evaporating would never be able to reduce the water temperature to the freezing point, since there would be too much heat to absorb.

The reader will readily see that such a plant would not be a commercial success since the ammonia would be lost after evaporation. The statement has already been made that ammonia liquid will evaporate if it is at a temperature above the boiling temperature corresponding to the pressure carried. Likewise, it will condense from a vapor into a liquid if its temperature drops below the boiling point for the pressure carried. As an example, it has been found that at 30 lb. absolute the boiling temperature of ammonia is 0.1 deg. F.; at 100 lb. absolute the boiling point is 56 deg. F., and at 153.9 lb. absolute the temperature of evaporation is 80 deg. F. Suppose the ammonia vapor as it leaves the evaporating flask is drawn into a cylinder where it is compressed by a piston, as in Fig. 7, and raised in pressure to 153 lb. absolute (138 lb. gage). In the

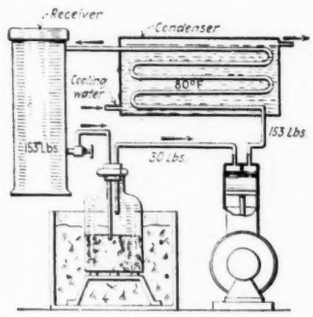


FIG. 7. CONTINUOUS REFRIGERATION SYSTEM

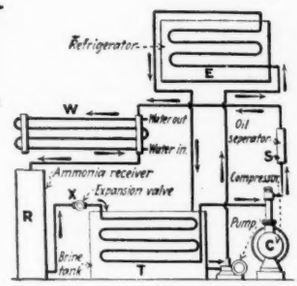


FIG. 8. PRACTICAL COMPRESSION PLANT

compression the ammonia gas gets very hot just as the air in an automobile tire pump will grow hot if pumped very fast. This increase in temperature is the result of the work done on the gas in compressing it. With a final pressure of 153 lb. when the pressure of the ammonia flowing from the flask to the compressor is 30 lb. the final temperature may be as high as 220 deg.

If the ammonia gas is to be condensed into a liquid, a temperature of less than 80 deg. must be secured, since the boiling temperature of ammonia under 138 lb. gage is 80 deg. F. To do this, the ammonia gas is passed through a series of coils in a water tank. The water cools the ammonia gas below 80 deg. and it condenses. The pressure remains at 153 lb., since fresh gas comes from the compressor to fill the space previously filled with the condensing vapor. Passing out through the coils, the liquid enters the receiver to be used over again.

The flask makes a poor evaporating vessel, since a very small amount of surface is exposed to the freezer box for a given volume of ammonia liquid. Consequently, coils are used in place of the flask, as indicated in Fig. 8. Pipe coils give a large outside surface for a given amount of ammonia. It is for this same reason that water-tube boilers evaporate more steam in a given time per cubic foot of volume than will a tubular boiler such as the Lancaster.

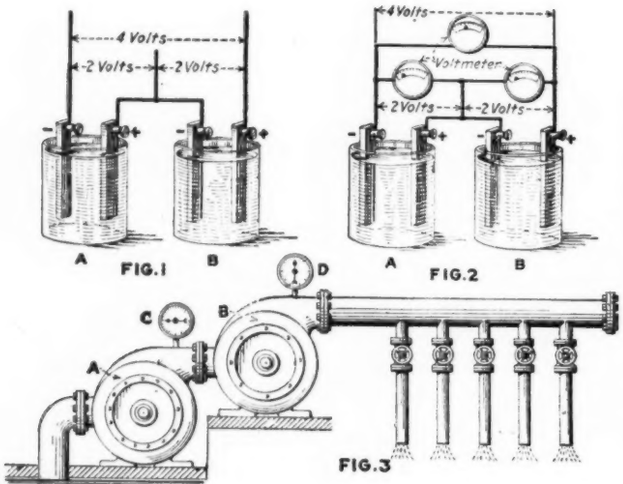
The reader probably has already decided that it would be poor economy to freeze ice around the coils and then break it up in removal. This practice would not be commercial, since the ice would be in small chunks and the tank would need to be filled with a new charge of water after each freezing. To avoid such waste of refrigerating effect, the tank *T* is filled with brine, which is a solution of water and calcium chloride. This solution freezes at 0 deg. F. or lower, depending upon the strength of solution.

The brine, after being chilled by the evaporating coils in the tank *T* to around 10 deg. F., can be pumped through coils located in a refrigerator *E*, in which case

we have a cold-storage system. In ice plants cans are placed in the brine tank between the coils containing ammonia. These cans can be filled with water, which is frozen into ice by the transfer of the heat in the water to the brine and from the latter through the iron coils to the ammonia liquid, which is boiling in the coils. Such an arrangement makes up the outlines of a refrigerating plant of the compression system, using ammonia.

Connecting Batteries or Generators

The two most common methods of grouping devices on electric circuits are in series or in parallel, the former of which will be discussed in this article. For low-head applications single-stage centrifugal pumps are used. After the head exceeds certain economical values, sufficient pressure cannot be developed in one stage to cause the water to flow against the head, therefore a



FIGS. 1 to 3. BATTERIES AND PUMPS CONNECTED IN SERIES

two-stage pump is used. In such a pump we might say that the two impellers are in series. Water is taken into the first stage and delivered to the second stage at, say, 25 lb., which is capable of discharging it at 50 lb. If sufficient pressure cannot be developed in two stages, then three, four or five impellers in series may be used to obtain the necessary pressure.

In electrical circuits it frequently becomes necessary to connect devices in series to increase the electrical pressure (volts). If one battery cell does not develop sufficient pressure to ring a bell, then it is necessary to connect two or more cells in series. In Fig. 1 are shown two battery cells grouped in this manner. It will be noted that the positive terminal of one cell connects to the negative of the other, with the remaining positive and negative terminal brought out to the external circuit. This is just the same as connecting the two pumps in series, Fig. 3. Pump *A* lifts the water from the reservoir and delivers it to pump *B* at, say 25 lb. which would be indicated on meter *C*. In passing through pump *B*, the pressure is increased, say, 25 lb. more and delivered to the pipe system at 50 lb., which is the pressure that will be indicated by meter *D*.

In Fig. 1, if a voltmeter is connected to cell *A*, it will indicate the pressure developed by this cell, say 2 volts. Likewise the voltmeter connected across cell *B* will indicate the pressure of this cell, say 2 volts. With the voltmeter connected across the two cells it will give the combined pressure of the two cells, or 4 volts, as shown in Fig. 2. If it is desired to connect four cells in series, then the positive of cell *A* is connected to the negative

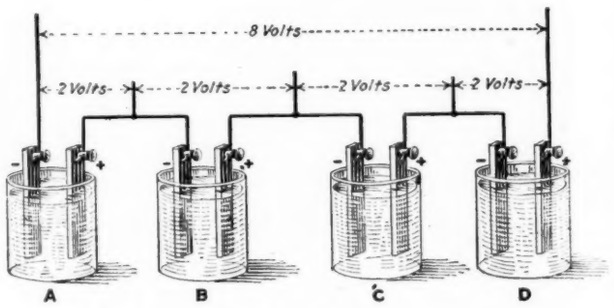


FIG. 4. FOUR BATTERY CELLS CONNECTED IN SERIES

of cell *B* and the positive terminal of cell *B* to the negative of cell *C* and the positive of cell *C* to the negative of cell *D*, as in Fig. 4. The two remaining positive and negative terminals are connected to the device to be operated, and if one cell develops 2 volts, then the four connected in series will develop $2 \times 4 = 8$ volts, as indicated in the figure.

The principle involved in connecting battery cells in series is one that is taken advantage of in the design of electric generators. In Fig. 5 is shown a diagram of a generator with a ring-type armature. If the armature is revolved in the direction of the arrow *A*, voltage will be generated in the winding in the direction indicated by the arrowheads. Following around through

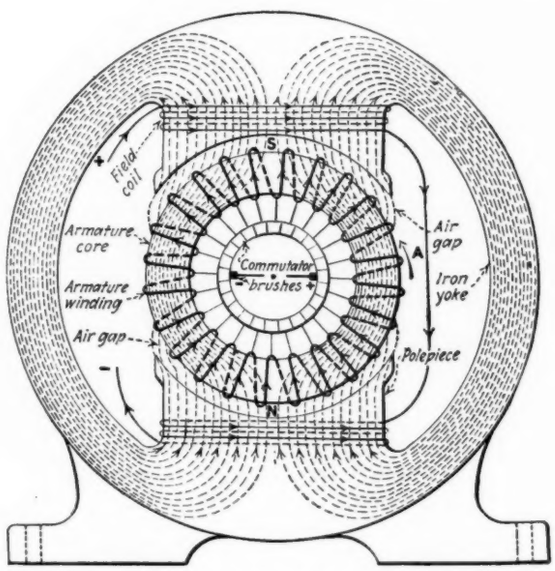


FIG. 5. DIAGRAM OF ELECTRIC GENERATOR

the part of the winding under the N pole, it will be found that the voltage produced in all the conductors is in the same direction, likewise under the S pole. This is just as for the four battery cells in Fig. 4. Tracing the circuit through from cell *A* to cell *D*, it is seen that

the voltage of all cells are in the same direction so that the pressure of one is added to that of the other, giving a total pressure at the outside terminals equal to the sum of that developed by each. In Fig. 5 if each of the 10 conductors in the magnetic field under the N pole developed 5 volts, then the 10 in series would produce $5 \times 10 = 50$ volts. The condition under the S pole is the same as under the N pole, therefore there will be a total of 50 volts developed in these conductors, and this is what a voltmeter would read if connected from the positive to the negative brush. This will be referred to again in the article dealing with parallel circuits.

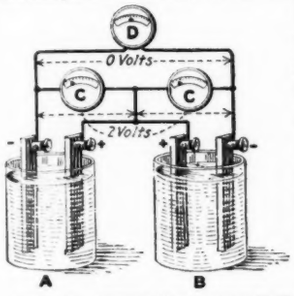


FIG. 6. TWO BATTERY CELLS CONNECTED IN OPPOSITION

In grouping voltage sources in series, care must be exercised not to get them connected in opposition. If two battery cells were connected as in Fig. 6, then although each cell may indicate two volts on a voltmeter, the voltage across the outside terminal will be zero, since the pressure of one cell opposes that of the other. A hydraulic analogy of this is given in Fig. 7, which shows two centrifugal pumps *A* and *B* connected in series, with the discharge of *A* connected to the discharge of *B*. With the two pumps driven and both developing equal pressure, say 25 lb., no water can flow, since the pressure tending to cause the water to flow in one direction is equal and opposite to the pressure tending to cause the water to flow in the opposite direction. A pressure gage connected at *C* will read the pressure developed by one pump just the same as when the voltmeters *C* and *C* read the voltage of one cell in Fig. 6. The pressure gage at *D*, Fig. 7, will read zero just as voltmeter *D* will in Fig. 6.

In a group of battery cells if one is connected in opposition to the other, then the volts at the terminals of the group will be reduced by an amount equal to twice that of the opposing cell. For example, in Fig. 8 if cell *C* is reversed, it will require a voltage equal to that of this cell to overcome its effect. Assume that

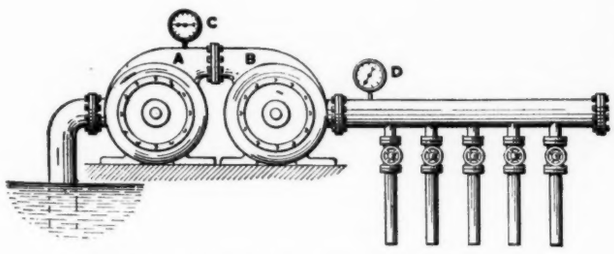


FIG. 7. HYDRAULIC ANALOGY OF FIG. 6

each cell develops 2 volts, then we may consider that the volts developed by cell *B* are required to neutralize those of cell *C*. This would leave only cells *A* and *D* effective, and a voltmeter connected across the outside terminals would read only 4 volts instead of 8, as would be the case if all cells were connected in to assist one another. The four cells in Fig. 8 may be compared to four men pulling on a rope. If they were all pulling in the same direction and each pulled 150 lb., they would develop a total pull of $150 \times 4 = 600$ lb. Now if one of them were to pull 150 lb. in the opposite direction, it would require the effort of one of the three remaining men to overcome the effort of the fellow pulling backward, therefore the effort tending to move the load is that of two men, or $150 \times 2 = 300$ lb. In combinations of voltage-producing devices the results will be the same

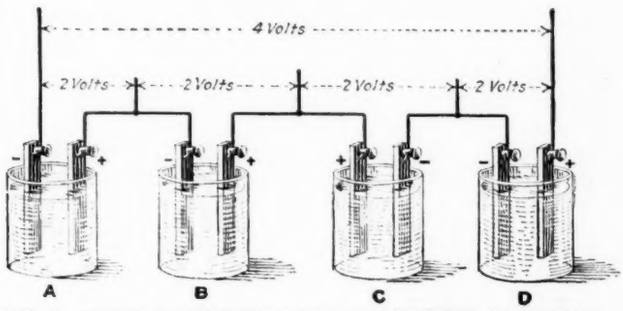
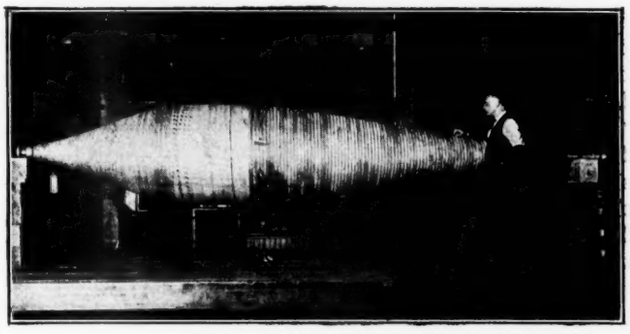


FIG. 8. FOUR BATTERY CELLS CONNECTED IN SERIES—CELL *C* REVERSED

as in a similar combination of mechanical forces. If we can obtain the resultant mechanical force, we may apply the same course of reasoning to obtaining the resultant electrical force (volts) or, as it is frequently called, electromotive force.

Million-Volt Transformer for Experimental Laboratory

The 1,000-kva. 1,000,000-volt transformer being built by the Westinghouse Electric and Manufacturing Co. for the experimental laboratory at Trafford City, Pa., is assuming its final shape. As an indication of the immensity of such a transformer, it can be stated that there are nearly 70 miles of wire in the windings. The terminal bushing, shown in the figure, is the largest


BUSHING FOR 1,000,000-VOLT TRANSFORMER

ever built in the Westinghouse shops. Special machines had to be fitted to turn the bushing on this account. Its length is 19 ft. and it is 41½ in. at its largest diameter and will weigh about 9,000 lb. when completed.

Slate and other incombustible in coal should be penalized for at least double the weight present. It is billed by the dealer as coal. Its presence reduces furnace capacity to a greater extent than the proportion of incombustible present; is a cause of waste of real coal; requires more than double the amount of labor for handling and is more damaging to the purchaser than to litter his coal pile, without charge, with so much broken stone.

Relation of Auxiliary Drives to Heat Balance

Direct Steam Drive—Motor Drive—House Turbines—Combination Drives—Feed-Water Heating by "Bleeder Condensers"

By J. R. McDERMET*

THE method of driving central-station auxiliary apparatus such as pumps, draft fans, etc., must conform to two basic conditions: Enough energy must be developed to perform the work required of the station auxiliaries, and this energy must be developed from steam in such a manner that all the available energy of the steam is extracted from it or that all the energy available but not utilized is returned to the cycle in a degraded heat form which may be used over again. Irrespective of the amount of steam that may be needed to generate the power required by the auxiliaries, the power measured in terms of station output, which is the ultimate unit of value, admits of little variation. The skill of the designer in the selection of the type of drive to employ is turned, therefore, in the direction of developing the power for the auxiliaries, not necessarily in the least consumption of steam, but in the least consumption of heat.

Electric Drive Is "Steam Efficient"

All-electric drive with energy supplied by the main units, neglecting for the moment the question of reliability in operation, fulfills the requirement that the power for the auxiliaries be developed with the least expenditure of steam, since the main unit is far more efficient than any prime movers that might be employed on the individual pieces of equipment. The intrinsic heat of the steam that the main unit rejects to the condenser is disproportionately large compared with the amount it uses, and this heat is lost. The heat rejected by an auxiliary turbine or engine and used to heat the feed water is saved. Excepting for the moment the use of steam bled from the stages of the main unit for feed-water heating, the use of main-unit energy is "steam efficient" and the use of an auxiliary source with feed-water heating is "heat efficient." Practical considerations of boiler operation, irrespective of the use of economizers, require that the feed water be heated. The problem of generating the energy for operating the auxiliaries, and of simultaneously utilizing the heat energy rejected, is the problem of heat balance and of station economy. Useful energy in the steam above the temperature to which it is desired to heat the feed water must be extracted, but the steam rate must be so adjusted that no more heat is available than is needed. Three methods of furnishing auxiliary power are available for accomplishing this, but they are not all equally desirable from an operating viewpoint.

The first method, and the one that has been in use the longest, employs steam drive, either turbine or engine, to operate the principal auxiliaries. Turbines, with or without reduction gears, are employed where their high rotative speeds can be utilized. Stoker drive has been uniformly relegated to engines in the past on account of slow speeds and large speed variation. Later "house-turbine" installations are employing variable-speed motors. Forced- and induced-draft fans in the older stations were driven by engines; the turbine and reduction gear or motor is largely supplanting the engine in later plants. This type of drive supplies more heat than is required for feed-water heating. For this reason some of the auxiliary units which may suffer momentary shutdown without interrupting the continuity of station service are driven by motors with power from the main units in order to equalize exhaust steam with heating demand.

The steam rate on the average type of turbine employed for auxiliary drive varies between 30 and 35 lb. per hp.-hr. With the present high pressures and superheats employed in station practice, these small turbines, within the pressure range they are able to utilize, cannot extract all the available heat from the steam so that the exhaust is sometimes superheated as much as one hundred degrees. Superheated steam, besides imposing temperature stresses upon materials, seriously limits the heat transfer of closed feed-water heaters and evaporators. Its use is dangerous in mixed-pressure turbines on account of temperature stresses. Where de-superheaters are used in connection with evaporators, the low conductivity of the superheated steam is overcome, but the de-superheater must be supplied with distilled water which is produced by the evaporators, thereby reducing their capacity.

Turbine drive or motor drive, as far as reliability of the driver is concerned, offers little choice; the electric motor in itself is apparently accredited with quite as high a factor of reliability as the turbine. It is, however, at a disadvantage in condenser pits where overhead floods are probable, and its application requires a much more specific knowledge of power requirements of the apparatus driven. Turbine drive will pull through periods of accidental overload without any manifestation of the overload where motors might fail from overheating. Auxiliary drive is, however, a service in which there is very little variation of load.

Insuring Steady Operation

It is essential that every precaution be taken to insure continuity of station service. Motor drive with energy from the main bus participates in all station power disturbances, and its promiscuous use increases the time required to re-establish service when it is interrupted on account of station and feeder short-circuits or generators falling out of step from power surges. Condenser circulating pumps, hydraulic air pumps and exciters are practically the only auxiliaries where a few seconds' interruption is disastrous. These are almost invariably turbine-driven or supplied either in duplicate or with duplicate motor drive from different sources of energy. Boiler-feed pumps with steam-driven units in reserve might properly be driven by motor. Practice, however, in all but a few of the very latest stations has assigned this auxiliary service to the turbine. It is even desirable that boiler auxiliaries participate in all losses of load on the main unit when evaporator makeup is employed. The safety-valve blow-off during periods of a few minutes total interruption

*Research Engineer, Elliott Company.

of service rises into such high values that the evaporators may not be able to make it up.

The latest boilers employ large tube areas exposed to the radiant heat of the fire and working at enormous rates of heat transfer. These tube surfaces must be kept absolutely clean on the water side, otherwise tube failures result. Raw makeup water is dangerous to such boilers. It is simpler and safer to start up induced- and forced-draft fans when service is resumed than to allow them to force the boilers to high ratings when there is no demand for steam. Fans usually possess sufficient energy of rotation to avoid flare-backs and explosions in the boiler settings when the driving energy is suddenly cut off.

The use of turbine drive, often in inaccessible places, increases the cost of supervision and complicates the steam piping. The small high-pressure piping is liable to leak; steam leaks also develop in the turbine glands. As a result, independent-turbine drive requires about 10 per cent makeup water; the house-turbine system of drive, which will be discussed later, requires only about 6 per cent. This is a decided saving where evaporator makeup is supplied. The complicated exhaust piping cannot be maintained under vacuum; therefore atmospheric feed-water heaters are imperative, regardless of the temperature of the feed water.

Flexibility of Control

Station load varies in accordance with outside demand; auxiliary-drive load remains approximately constant. The turbine drive, with the necessity of locating the auxiliaries throughout the plant, does not permit accurate control of the feed-water temperatures. The system is inherently inflexible in the regulation of heat balance. For the greatest economy of operation the exhaust-steam supply is based on the highest water temperature that the heaters and boiler-feed pumps can carry during the "valleys" in the station-load curve; temperatures drop off as the load rises.

One large central station of comparatively late design employs duplex drive on all auxiliaries. Such a system is inherently expensive, but provides the maximum of reliability and flexibility in control of feed temperature. From a temperature viewpoint it is much more difficult to centralize the control than with the house-turbine system.

The second general method of driving the station auxiliary apparatus, and one which is at present greatly in fashion, is a house turbine. The house turbine is a complete turbo-generator unit sufficiently large in capacity to carry the motor-drive load of all auxiliary apparatus. This turbine is often designed to operate under a moderate vacuum. Owing to its larger size it is possible to employ in it more efficient staging, rotative speeds and number of stages. The water rate, running atmospheric, varies between 16 and 18 lb. per hp.-hr. The horsepower steam cost is, therefore, practically half that of the small auxiliary turbine even when the efficiency of electric transmission is considered.

The exhaust of the house turbine is used for feed-water heating through a condenser heater, which is nothing more than a jet condenser with a modified spraying arrangement designed to keep up the efficiency of the sprays with a wide range of quantity of injection water. Condensate from the main condenser is supplied as cooling water, and some form of air-removal apparatus is employed. The supply of condensate for cooling water varies with the station load, so that steam from the house turbine must be controlled to maintain a constant feed-water temperature. The temperature desired for the feed water limits the vacuum attainable for the condenser water. With economizer installations, where feed-water temperatures as low as 140 deg. F. are permissible, it is possible, by throwing the duty of the extra heating upon the economizer, to produce a substantial reduction in the water rate of the turbine over that given herein.

Feed-Water Temperatures

The best heat-balance condition for a station without economizer equipment is obtained with a feed-water temperature of from 205 to 212 deg. F. With lower temperatures corrosion difficulties are encountered. This temperature does not permit carrying a vacuum on the house turbine and the heater condenser. The heater condenser is, however, cheaper than the atmospheric open heater; and the house turbine extracts more energy from the steam than the smaller unit turbines, although at high steam pressures and superheats the exhaust from the house turbine also is wastefully superheated. Stations equipped with economizers may economically utilize feed-water temperatures as low as 140 deg. F. This temperature range permits vacuum in the heater condenser. The heater condenser is, however, relatively inefficient as a vacuum-producing device compared with the high-vacuum jet condenser, on account of the necessity of handling large steam-air volumes in the air pump. With vacuum operation the superheat of the turbine exhaust relative to the vacuum decreases, the turbine expansion becomes more efficient and the water rate is reduced. The exhaust piping between the turbine and the heater condenser, which is often long and complicated compared with the short, direct connection employed in high-vacuum work, requires careful maintenance because the condenser heaters are easily "air drowned."

Types of Motors

The remarks made regarding the reliability of electric motors for driving the individual auxiliaries apply to house-turbine systems also. The induction motor is particularly adapted to this kind of service and is universally used where its constant-speed characteristics permit. Stoker and fan drives require an adjustable-speed motor, which is generally of the direct-current type because of the higher cost and relatively low reliability of the alternating-current commutator motor. This complicates the house-turbine system with the necessity of using motor-generator sets to convert from alternating to direct current.

The control of house-turbine load provides an extremely sensitive and precise means of regulating feed-water temperature. Several methods have been used as the basis of this control. The house-turbine generator may be synchronized through a transformer bank with the main generators and permitted to exchange load with them. This method permits the house generator to participate in all outside power disturbances and is rarely used, although the connection is uniformly provided, partly at least to enable the station to be put in initial operation with power from the network.

Duplicate power buses may be carried to some of the selected auxiliaries whose continuous operation is not essential in load disturbances. One bus is supplied with power from the house turbine and the other with power from the main generators. Control of the feed-water

temperature is obtained by shifting motor load from one bus to the other. This method is extremely simple, but lacks in flexibility since the control cannot be centralized.

A synchronous generator driven by an induction motor supplied from the main bus may carry the variations in auxiliary load necessary to regulate the feed-water temperature. The load may be shifted from motor generator to house turbine or vice versa by the simple expedient of slightly altering the frequency of the house generator under control of the switchboard operator.

These two general methods—independent turbine drive, and house turbine with motor drive—are both widely employed, although the latter is much newer in its application. Still a third method, which for the purpose of this article and until the nomenclature is established by usage, may be designated as the "bleeder

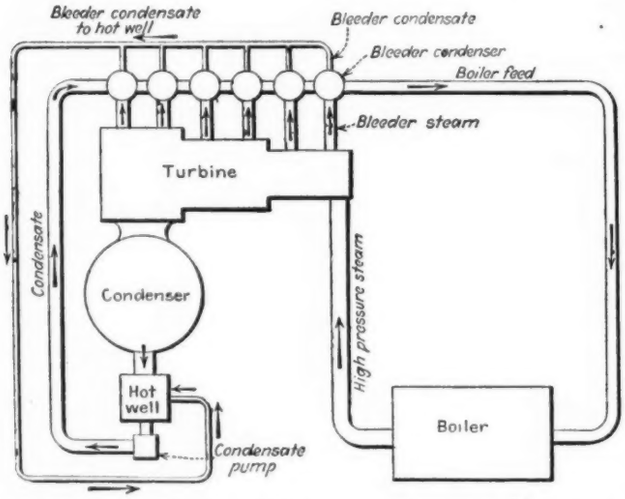


DIAGRAM SHOWING METHOD OF HEATING FEED WATER BY A SERIES OF "BLEEDER CONDENSERS"

condenser method" is contemplated in a modified form for a station under construction. It is extremely simple in apparatus but rather complicated in theory, and a word of explanation regarding the fundamentals of the theory is necessary for an understanding.

Any discussion of power-plant efficiencies based upon energy cycles, whether Rankine or Carnot, is predicated upon an inexhaustible supply of heat stored at higher temperature. This supply of heat is not available in nature, and to get it, it is necessary to burn coal in the presence of air. Both air and coal are introduced into the furnace at low temperatures and must be raised to high temperatures. The boiler is intrinsically unable to reduce the products of combustion to the initially low temperature at which they entered the furnace. Economizers are added to lower the temperature further. In the final analysis the economizer, however desirable its use may be from a practical standpoint, is simply a means of recovering the heat that was lost in the combustion process because the raw materials were introduced in a cold state. It might quite as well be replaced by regenerator stoves for preheating the supply of combustion air. It is a device for improving the thermal efficiency of the boiler, and its use has no bearing on the cycle efficiency of the plant, since in either event all the heat has to be supplied by the boiler plant.

It is obviously wasteful to use steam for water heating at a higher temperature than it is desired to heat the water. Saturated steam expanding in the main turbine passes through a gradual and uniform change of temperature from that of the boiler into which water is fed to that of the condenser from which it is taken. If it were possible to disregard the water pressure, steam could be taken from the turbine through a series of connections and mixed with the feed water, affording gradual heating. An actual installation operating on this principle might use a series of closed heaters as indicated diagramatically in the sketch, these heaters acting as bleeder condensers. If the number of bleeder connections be considered as infinite, such a scheme will fulfill the following condition: In each one of this infinite series of stages, heating steam and heated water will vary from each other only by an infinitesimal fraction of a degree; and at each stage the main turbine, preliminary to the bleeding of the steam, will have extracted from it all the useful mechanical energy that human ingenuity is able to accomplish. The temperature range of the steam will be precisely the range of water heating.

The theoretical upper limit of the thermal efficiency of a turbine without "bleeder condensers" is that of the Rankine Cycle. It can be proved mathematically that the addition of an infinite number of "bleeder condensers" raises this limit to that of the Carnot Cycle. The difference in absolute efficiency is about 2 per cent in favor of the Carnot. Expressed in per cent efficiency on the Rankine-Cycle basis, the gain is approximately 17 per cent.

Obviously, this increase in efficiency is not attainable in practice. The necessity of using only a limited number of closed heaters as "bleeder condensers" to simplify piping, lack of equilibrium between heating steam and water in this reduced number of stages, temperature lag between the steam and water side of the bleeding condenser tubes, and increased hydraulic loss in the "bleeder condenser"—all impose limits. It appears, however, that with two bleeder condensers the attainable increase in Rankine-Cycle efficiency lies between 8 and 10 per cent.

Electric drive of the auxiliaries from the main bus is the only available method. Its use will, therefore, be possible only when the station is part of a network of high aggregate capacity. The reliability against outside disturbance is low. Practical considerations will probably require some steam-driven auxiliaries, and an economizer will be employed for the higher ranges of feed temperatures.

In the header type of straight-tube water-tube boiler the most active circulation is through the lowest row of tubes and moves from the lowest to the higher header. The circulation diminishes in this direction in the tubes, above, until near the middle row it is slight and may be in either direction. Above these the circulation is in the opposite direction to that in the lower tubes. This has been clearly shown by propellers in the tubes, the shafts of which pass out through stuffing boxes in the handhole caps opposite the tubes, the rotations being registered by an electrical device. The foregoing refers particularly to cross-drum boilers, but in boilers with longitudinal drums the water in all the tubes may sometimes move in one direction and the return may be through the drum.

Power-Plant Accounts—XIII. Closing Ledger Accounts

By WILFRED A. MILLER

THE principles of bookkeeping are based merely on a systematic representation of facts as they occur, and there is nothing difficult about grasping the essential facts and setting up an accounting system of our own, using our own devices to represent the facts that we have to record. On the other hand, a good deal of thought and study have been given to the means to be used for representing facts in a bookkeeping way, and it will be preferable for us to follow such a standardized routine rather than venture on a design of our own of which we are not likely to realize the shortcomings until we have done considerable work with it. To make changes then would be a cumbersome and thankless job. We are already acquainted with quite a number of the conventions used in standard bookkeeping practice and are therefore prepared to consider some others.

One of the things that crop up periodically, is what is called the closing of ledger accounts. This operation is sometimes performed once a month, but more usually once a year. There may also be occasions upon which it occurs at no specific time. Just for the practice of it we may close some or all of our ledger accounts when we have been keeping our books, say, for four months. In order to give a clearer description of what is meant by closing an account, reference is made to Figs. 1 and 2. The former is a representation of the Total Cost account at the end of April before closing it, and the latter shows the same account after closing. Little need be said about the appearance of the account before closing. It is just in the condition in which it ordinarily would be at the end of a month. The total debits to date amount to $8,180 and the total credits to $210, leaving a debit balance of 8,180 — 210 = $7,970, as shown by the small figures.

> This is the thirteenth of a series of articles written in conversational style and treating the subject of power-plant accounts in a thorough, yet simple manner. They were prepared primarily for the guidance of the operating engineer who wishes to keep track of the cost of the power he is making, but who knows nothing at all about bookkeeping. Others may find the articles helpful in clearing up their ideas on the subject. This installment shows how to "close" the ledger accounts.

The first step in closing is to add the columns as has been done in Fig. 1 and find the difference between the two sides of the account, which is known as the balance of the account, and which in this case, as already stated, amounts to $7,970. An entry of this amount is then made on the side with the *smaller* total, in our case the credit side. As shown at (*a*) in Fig. 2, the entry is made on the last day of the month and the word "Balance" is written in the explanation column. It is a good scheme to make the entire entry, date, explanation and amount in red pencil or ink. This will distinguish the entry from others in the account, because it is of a special kind, whose only purpose is to make the totals of the two sides of the ledger account add up to the same amount.

The next step is to rule a line at the foot of the longer columns of the two, as at (*b*), and then to rule a similar line in the shorter column exactly opposite the first line, as at (*c*); that is, the second line is not drawn underneath the last entry in its column, but takes its position from the other line no matter how much of its column remains unfilled. This is done to keep the two sides of the account at the same level in the same way as when we continue an account from one page to another. Having ruled the lines (*b*) and (*c*), the next thing is to write in the totals as at (*d*) and (*e*). Since the amount that we entered at (*a*) is the difference between the columns as they appear in Fig. 1, it is obvious that (*e*) must add up to the same total as (*d*).

The account is then "closed," and to indicate that fact we rule double lines under the totals, as shown at (*f*) and (*g*). It is usual to draw all lines such as (*b*), (*c*), (*f*) and (*g*) in red pencil or ink, although it is a convention that it is not important to follow. What is of importance, however, is to recognize the fact that a double line, such as (*f*) or (*g*), always indicates that the account is "closed" above that line, and that therefore no subsequent entries may be added to the total that appears over the double line. So far as future work on the account is concerned, it is to be considered as having been chopped off at the point where the double lines have been drawn.

Having gone thus far in our closing, we come face to face with the fact that before closing the account it indicated that our total cost up to the end of April was $7,970, as shown in Fig. 1, whereas after closing we do not seem to have any difference between the two sides of the account; that is, our cost to date has the appearance of being zero. If we were to continue with the May entries we would, of course, be building up a new total cost from the first of May onward, but since we cannot go back of the double lines, we would seem to have lost track of the cost prior to May 1. This difficulty is readily overcome by entering the balance of the account under the double line on the proper side of the account, as at (*h*) in Fig. 2. In fact, we have no choice but to do this if we wish our bookkeeping to mean anything. When we made the entry at (*a*), we did so only for the purpose of closing the account, but by doing so we made an entry that changed the condition of the account arbitrarily. That is, we were not recording a transaction of any kind, we were merely jotting down a figure because we wanted to make the amount at (*e*) come out the same as the one at (*d*). Now of course we cannot do any such juggling as that with our accounts. Under all circumstances they must show the facts. Hence, amounts must be so added that the account will not be changed thereby.

To do this is quite a simple matter. Thus, if we

wish to add $7,970 to the credit side of the Total Cost account in Fig. 1, all we need do to compensate for it is to add the same amount to the debit side. Since we have added the same amount to both sides, it would not change the amount of total cost that the account reveals.

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TOTAL COST

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
		Brought forward	65	6000	—			Brought forward	65	170	—
1920 Apr	30	Fuel		1400	—	Apr	30	Ash Removal		40	—
	30	Water		100	—					210	—
	30	Labor		400	—						
	30	Repairs		200	—						
	30	Miscellaneous		80	—						
		7970 —		8180	—						

FIG. 1. TOTAL COST ACCOUNT FOR APRIL BEFORE CLOSING

However, to add the same sum to both sides before attempting to close the account would leave us exactly where we started from; the total of the debit side would add up to more than the credit side, so that the account could not be closed. To get around this difficulty, the entry on one side is made above the closing lines, while that on the other side is made below them. Thus in Fig. 2 the balance is written in at (*a*) above the closing line in the credit column and is written in again on the debit side, but at (*h*), below the closing line. Also the date of entry (*h*) is put down as the first day of the

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TOTAL COST

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
		Brought forward	65	6000	—			Brought forward	65	170	—
1920 Apr	30	Fuel		1400	—	1920 Apr	30	Ash Removal		40	—
	30	Water		100	—		30	Balance	(a)	7970	—
	30	Labor		400	—					8180	—
	30	Repairs		200	—						
	30	Miscellaneous		80	—						
		7970 —	(b)	8180	—						
			(d)	8180	—				(c) (e)	818	—
May	1	Balance	(f) (h)	7970	—				(g)		

FIG. 2. SAME AS FIG. 1, AFTER CLOSING

coming month, whereas the date of entry (*a*) is the last day of the current month.

The kind of entry used in closing is the only one that should be made in any ledger account directly. All others should be made as postings from entries in our journal. This is a rule of bookkeeping that has been found to have so many good points that it has been generally adopted.

If we go back over some of the work we have done on previous occasions, we shall find that we have violated this rule in the past. This need not give us any concern since we are only learning how to do these things, and if, for the present, we get the correct results by any method at all, we may be satisfied with learning more about the correct technique of the work as we go along. The principal case of this kind with which we have dealt so far is the transfer of individual expense-account totals to the Total Cost account. In doing this we have simply gone over the individual accounts, such as the Labor, Fuel and Water accounts, at the end of each month and entered in the Total Cost account the amounts we found in the individual accounts. What we really should have done, and what we will do from now on, is to make each of these entries through the medium of a journal entry.

REPAIRS

DATE		EXPLANATION	REF	AMOUNT		DATE		EXPLANATION	REF	AMOUNT	
1921 Apr	4	Gaskets		6	32	1921 Apr	26	Allowance on boiler repair bill		12	25
	12	Part for traps		10	75						
	20	Boiler repairs		248	59						
	28	Bearing Brasses		31	17						
				296	83						

FIG. 3. REPAIRS ACCOUNT FOR APRIL BEFORE CLOSING

There is something else that we should take into consideration, too, and that is this: We are placing certain expense amounts in the Total Cost account. If we do this, we ought to remove these amounts from the accounts from which we take them, so that our ledger will not make it appear as if we had a total expense of a certain amount and then a lot of individual expenses besides. To show just how this scheme would work out, let us take one of our individual accounts and apply the process to it. Thus, let us suppose that our Repairs account has been started in April and that we are now at the end of the month and that at this time the Repairs account looks like Fig. 3. The net total at the end of April is evidently $284.58, and it is this amount

	1921 Apr	30	Total Cost	Transfer from Repairs	284	58			
		30	Repairs	Transfer to Total Cost			284	58	
		30	Total Cost	Transfer from Labor	1000	—			
		30	Labor	Transfer to Total Cost			1000	—	
		30	Total Cost	Transfer from Fuel	5000	—			
		30	Fuel	Transfer to Total Cost			5000	—	
		30	Total Cost	Transfer from Water	100	—			
		30	Water	Transfer to Total Cost			100	—	
		30	Total Cost	Transfer from Lubricants	30	—			
		30	Lubricants	Transfer to Total Cost			30	—	
		30	Total Cost	Transfer from Scale Removal	50	—			
		30	Scale Removal	Transfer to Total Cost			50	—	
		30	Total Cost	Transfer from Misc. Supplies	20	—			
		30	Misc. Supplies	Transfer to Total Cost			20	—	
		30	Total Cost	Transfer from Indirect Expense	800	—			
		30	Indirect Expense	Transfer to Total Cost			800	—	
		30	Ash Removal	Transfer to Total Cost	100	—			
		30	Total Cost	Transfer from Ash Removal			100	—	

FIG. 4. JOURNAL ENTRIES FOR TRANSFERRING NET TOTALS OF EXPENSE ACCOUNTS TO TOTAL COST ACCOUNT

that is to be transferred to the Total Cost account. Let us first suppose that, if we had illustrations of our other expense accounts, they would show the following net totals. Labor, $1,000; fuel, $5,000; water, $100; lubricants, $30; scale removal, $50; miscellaneous supplies, $20; indirect expenses, $800; ash removal, credit balance, $100.

We now wish to remove all these amounts from their individual accounts and place them in the Total Cost ac-

TOTAL COST

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF	AMOUNT	
1921 Apr	30	Repairs		284	58	1921 Apr	30	Ash Removal		100	—
	30	Labor		1000	—						
	30	Fuel		5000	—						
	30	Water		100	—						
	30	Lubricants		30	—						
	30	Scale Removal		50	—						
	30	Miscellaneous Supplies		20	—						
	30	Indirect Expenses		800	—						
				7100	58						

FIG. 5. TOTAL COST ACCOUNT WITH ITEMS OF FIG. 4 POSTED

count in order to get the combined total cost for the month. To do this, we must make a set of journal entries such as those indicated in Fig. 4 From the illustration it will be seen that we have debited the Total Cost account with the balance of each account and that we have credited the account itself with that balance, with the exception of the Ash Removal account, in which case we have debited the account itself and credited the Total Cost account. The result on the Total Cost account will be that shown in Fig. 5. The result on each of the individual accounts will be similar to that indicated for the case of the Repairs Account in Fig. 6. From the latter we see that the two sides of the account have been made of the same amount; that is, they have been "brought into balance," as it is expressed. This we should expect because we deliberately credited the account with its own balance. The same will naturally

REPAIRS

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1921 Apr	4	Gaskets		6	32	1921 Apr	26	allowance on boiler repair bill		12	25
	12	Parts for traps		10	75		30	Transfer to Total Cost		284	58
	20	Boiler repairs		248	59					296	83
	28	Bearing Brasses		31	17						
				296	83						

FIG. 6. SAME AS FIG. 3, BUT WITH REPAIRS ITEM OF FIG. 4 POSTED

hold true of all the other accounts, so that if we had pictures of them we should find that all of them are likewise "in balance." It will be noted that this fact is made apparent in the account by crossing out the small figures which up to now had shown the balance.

Since all the individual expense accounts are in balance, we have a splendid opportunity of ruling them off; that is, closing them at the end of each month and making a fresh start for the new month. Let us do this henceforth at the end of every month. To show what

REPAIRS

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1921 Apr	4	Gaskets		6	32	1921 Apr	26	allowance on boiler repair bill		12	25
	12	Parts for traps		10	75		30	Transfer to total cost		284	58
	20	Boiler repairs		248	59					296	83
	28	Bearing Brasses		31	17						
				296	83						
1921 May	10	Rheostat parts		9	02						
	25	Conveyor repairs		84	37						

FIG. 7. REPAIRS ACCOUNT CLOSED AT END OF APRIL AND WITH MAY ENTRIES STARTED

happens, attention is called to Fig. 7, in which the Repairs account of Fig. 6 has been ruled off, and in which some entries for May have then been made to show how nicely each month is separated from the others by this method. The net effect of what we have done is to take away from each individual account the amount accumulated in it during the month, thus reducing it to zero, and transferring this amount to the Total Cost account.

If we look over our ledger, we shall find that we can go still a step farther in the matter of closing out others of the accounts at the end of each month. It will be remembered that we obtained the profit made in a month by looking up the net totals of the Income account and the Total Cost account and then subtracting the latter from the former, which amount we entered in the Profit and Loss account. Here again, it will be recognized that we made in the ledger an entry that did

INCOME

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF	AMOUNT	
						1921 Apr	30	Dept. A		2000	—
							30	Dept B		1500	—
							30	Dept C		3500	—
							30	Dept D		500	—
										7100	—

FIG. 8. INCOME ACCOUNT AT END OF APRIL

not come through the journal, and therefore we should in the future correct ourselves on this point by making a journal entry and posting from that in accordance with the rule that we have laid down for ourselves. This, however, is only a minor detail in what we are coming to. The point is that we wish to get the difference between the Income and the Total Cost accounts into our ledger account for Profit and Loss. The method originally used—just entering the amount in the Profit and Loss account—accomplished this, and so would the method of first putting it through the journal. How-

ever, there is still a third method that may be employed, which, in addition to accomplishing our purpose, also accomplishes other results as we shall see hereafter.

	1921 Apr.	30	Profit and Loss	Transfer from Total Cost	7184	58		
		30	Total Cost	Transfer to P. & L.			7184	58
		30	Income	Transfer to P & L	7500	—		
		30	Profit and Loss	Transfer from Income			7500	—

FIG. 9. JOURNAL ENTRIES TO TRANSFER NET TOTALS OF INCOME AND TOTAL COST ACCOUNTS TO PROFIT AND LOSS ACCOUNT

TOTAL COST

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1921 Apr.	30	Repairs		284	58	1921 Apr.	30	Ash Removal		100	—
	30	Labor		1000	—		30	Transfer to P & L		7184	58
	30	Fuel		5000	—					7284	58
	30	Water		100	—						
	30	Lubricants		30	—						
	30	Scale Removal		50	—						
	30	Misc. Supplies		20	—						
	30	Indirect Expenses		800	—						
				7284	58						

FIG. 10. TOTAL COST ACCOUNT AFTER POSTING ENTRY OF FIG. 9

To explain the method referred to, let us assume that at the end of April our Total Cost account looks like Fig. 5 and our Income account like Fig. 8. Evidently,

INCOME

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1921 Apr.	30	Transfer to P & L		7500	—	1921 Apr.	30	Dept. A		2000	—
							30	Dept. B		1500	—
							30	Dept. C		3500	—
							30	Dept. D		500	—
										7500	

FIG. 11. INCOME ACCOUNT AFTER POSTING ENTRY OF FIG. 9

PROFIT AND LOSS

DATE		EXPLANATION	REF	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1921 Apr.	30	Total Cost		7184	58	1921 Apr.	30	Income		7500	—

FIG. 12. PROFIT AND LOSS ACCOUNT AFTER POSTING ENTRIES OF FIG. 9

our income for the month is $7,500 and our net cost, $7,184.58, so that our profit is 7,500 — 7,184.58 = $315.42. We could take this amount and put it into the Profit and Loss account either directly, or more properly through the medium of a journal entry, as already discussed. However, instead of doing this, let us follow the procedure outlined herewith. Let us remove from the Income account the amount that we have accumulated in it and stick it into the Profit and Loss account. Also, let us do the same thing for the Total Cost account and see what the result of our experiment will be. In order to accomplish our purpose, we will, of course, first make journal entries for the transactions.

INCOME

DATE		EXPLANATION	REF	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1921 Apr.	30	Transfer to P & L		7500	—	1921 Apr.	30	Dept. A		2000	—
							30	Dept. B		1500	—
							30	Dept. C		3500	—
							30	Dept. D		500	—
				7500	—					7500	—

FIG. 13. SAME AS FIG. 11, AFTER CLOSING

These entries will be like the ones in Fig. 9. Let us post them. Then the Total Cost, Income and Profit and Loss accounts will look like Figs. 10, 11 and 12, respectively. An examination of Fig. 12 will show that the effect on that account is precisely the same as entering the profit in it directly, since the balance shown in the small figures is the profit we would have entered; namely, $315.42. Consequently, this method serves as well as the others to give us the correct answer in our Profit and Loss account. On the other hand, if we examine the Total Cost and the Income accounts, we see that by means of our entries we have brought each of them into balance. This being the case, we will take the opportunity to rule them off, just as we did the

TOTAL COST

DATE		EXPLANATION	REF.	AMOUNT		DATE		EXPLANATION	REF.	AMOUNT	
1921 Apr.	30	Repairs		284	58	1921 Apr.	30	Ash Removal		100	—
	30	Labor		1000	—		30	Transfer to P & L		7184	58
	30	Fuel		5000	—						
	30	Water		100	—						
	30	Lubricants		30	—						
	30	Scale Removal		50	—						
	30	Misc. Supplies		20	—						
	30	Indirect Expenses		800	—						
				7284	58						
				7284	58					7284	58

FIG. 14. SAME AS FIG. 10, AFTER CLOSING

individual expense accounts before. The result will be that they will look like Figs. 13 and 14, respectively. Here again, it has become possible to close accounts at the end of the month without making our records tell any falsehoods, and has left the way open to keep our accounts month by month, so that each period will be separate from any other.

A Simple Method of Finding Steam Consumption of Small Turbines

Small turbines using superheated steam frequently have a superheated exhaust. In such cases it is a simple matter to determine the heat in the inlet and exhaust steam from measurements of pressure and temperature. The difference between the heat at inlet and exhaust goes mostly into useful work and the remainder to the outside losses of bearing friction, radiation and leakage. The total of these outside losses is practically constant for all loads and needs to be determined only once for a given turbine. When this quantity has once been measured, it is a simple matter to figure the water rate at any load by measuring the pressure and superheat of the inlet and exhaust steam at the given load.

THE use of superheated steam in auxiliary turbines exhausting at atmospheric pressure usually results in the steam being superheated at exhaust. The fact that temperature and pressure completely determine the total heat of superheated steam has led to the suggestion that for such a case the water rate of the turbine may be determined by simple temperature and pressure measurements at inlet and exhaust.

It is evident that, with such measurements and the steam tables for superheated steam, it is an easy matter to find the total heat in the steam entering and leaving the turbines. The difference is the heat taken out of one pound of steam by the turbine. Most of this must go into power. The only way it could avoid doing so would be to get out of the body of the turbine as radiation, outside gland loss, friction of bearings, friction of governor drive, power to operate water glands, etc. The total of these amounts, ordinarily, to only a small fraction of the heat drop from the inlet steam to exhaust steam.

This at once suggests a remarkably simple method of testing such turbines. It might be assumed, for instance, that 90 per cent of the heat drop through the turbine goes into useful work. Since one horsepower-hour is equal to 2,546.5 B.t.u., it would then only be necessary to divide 2,546.5 by 90 per cent of the neat drop in order to find out how many pounds of steam were being used per horsepower-hour. The factor (in this case 90 per cent, or 0.9), by which the heat drop must be multiplied to get the part of it that actually produces power, will be called the "water-rate factor" and be represented by the letter *F*.

The Mechanical Engineering Department of Johns Hopkins University was recently asked to investigate the feasibility and accuracy of this method of determining water rate, assuming *F* to have a value around 0.9, which value was looked upon as a reasonably close approximation. The problem was undertaken by Messrs. Stansbury and Weil, under the direction of Professor A. G. Christie in the laboratory, where two 100-kw. turbo-generator units were available with complete facilities for the accurate measurement of all necessary quantities.

Before doing any experimental work, Messrs. Stansbury and Weil made a theoretical study of the problem which led them to the conclusion that the water-rate factor *F* could not be constant at 0.9 or any other value, but varies widely with the load on the machine and also with the machine. The final result of this study was the preparation of the chart shown in Fig. 1, in which the horizontal scale represents the percentage of load at which the turbine is operating and the vertical scale the factor *F*. It will be noted that curves are given for various values of p_f, which is the horsepower equivalent

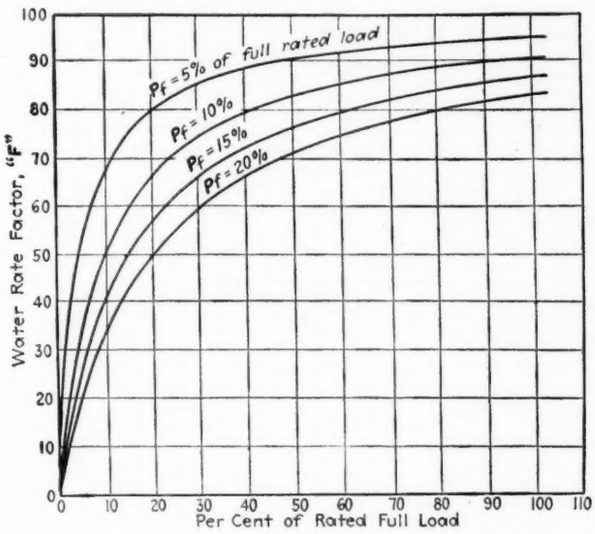


FIG. 1. CURVES TO DETERMINE WATER-RATE FACTOR FOR ANY TURBINE AT ANY LOAD

of the energy required to keep the turbine turning over at full speed and no load. This is made up of the losses previously mentioned.

It was reasonable to assume that p_f would not change appreciably with the load on the turbine, but that it would be different for different turbines. The experimental work demonstrated that this was the case. It then became evident that if p_f could once be accurately determined for a given turbine the water rate at any load could be determined by the simple process of measuring the pressure and temperature of the inlet and exhaust steam at the given load and making a few simple computations.

The value of p_f can be found by making a single test at any known load on the turbine. In this preliminary test it is necessary to measure not only the pressure and temperature of the inlet and exhaust steam, but also the amount of steam used per hour. Where possible the turbine should be disconnected from the apparatus it is driving, so that it can run at zero load. In that case the method of computing p_f is as follows: (1) From the superheated steam tables get the heat in the inlet and the exhaust steam and take the difference. (2) Multiply this difference by the pounds of steam used per hour; this gives the heat wasted per hour to keep the turbine spinning at no load. (3)

[1]The curves in Fig. 1 were plotted from the following relation: Water-rate factor *F*, equals the brake horsepower divided by the sum of the brake horsepower and p_f. In Fig. 1 both the brake horsepower and p_f are given as a percentage of the rated capacity, so that the curves can be used for any turbine.

Divide this by 2,546.5 to get p_f. (4) Divide p_f by the rated horsepower of the turbine and multiply it by 100 to get p_f expressed as a percentage of the rated horsepower of the machine.

Running the test for p_f at no load in this way eliminates the necessity of measuring the horsepower output of the turbine. Where the turbine is direct-connected to a generator, it may be impracticable to disconnect it, so that the best that can be done is to run with no load on the generator. This, of course, leaves a small load on

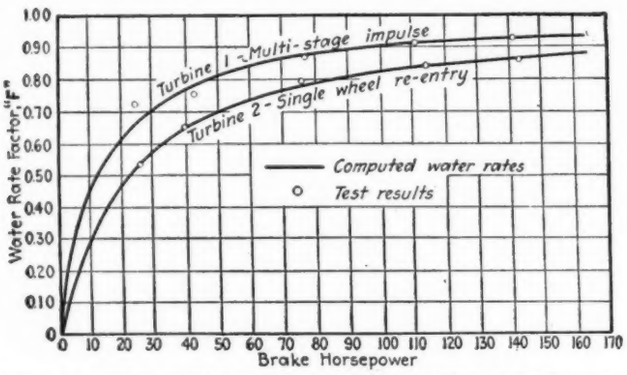


FIG. 2. COMPARISON OF COMPUTED WATER RATES WITH THOSE DETERMINED BY ACTUAL TESTS

the turbine. If curves are available showing the power required to run the generator at various outputs, including zero output, it is possible to run the test for p_f with some load on the turbine proper. In figuring such a test the method is as follows: (1) Get the difference between the heat in a pound of inlet and exhaust steam exactly as before. (2) Multiply this by the pounds of steam used per hour. (3) Divide this product by 2,546.5. The result is the sum of p_f and the developed horsepower. (4) Subtract the power delivered by the turbine. The remainder is p_f.

When p_f has once been found, as described, it need never be determined again. It is, however, desirable to repeat the determination of p_f at least once as a check, and use the average of the results.

The method of getting the water rate at any load after p_f is known has already been suggested. The procedure is as follows: (1) Run the turbine at the load at which the water rate is desired, measuring only the pressure and temperature of inlet and outlet steam. (2) From the steam tables get the total heat in a pound of inlet and exhaust steam and take the difference. (3) Get the water-rate factor F for the given horsepower output and the previously determined value of p_f for the turbine, using the curves of Fig. 1. (4) Multiply this factor by the difference between the heat in one pound of inlet and exhaust steam and divide the result into 2,546.5. The quotient is the water rate, or pounds of steam consumed per brake horsepower per hour.

In order to test the accuracy of the foregoing analysis in practice, tests were made with superheat on a 100-kw. single-stage impulse turbine fitted with reversing chambers and on a 100-kw. multi-stage impulse turbine of the Rateau type. These non-condensing units were run at about 150 deg. superheat, so that the steam was still superheated at exhaust. Power output was measured electrically; the steam consumption determined by weighing tanks; inlet and outlet temperatures read by mercury thermometers, applying stem corrections. Efficiency curves for the generators were available to calculate brake-horsepower output.

Using the value of p_f found for the two turbines in connection with the curves of Fig. 1, the water-rate factors for the two turbines were determined. These were plotted as the two curves of Fig. 2. Then actual steam-consumption tests were run at five different loads. Pressure and temperature measurements were also made at each load to get the actual water-rate factors. These were plotted in the circles and show a very close agreement with the computed curves, indicating a high degree of reliability for this method of testing.

It is well to note a possible source of considerable error in the application of this method; namely, the temperature measurements at inlet and exhaust. These temperatures must be determined with the greatest accuracy. Possibly some instruments other than mercury thermometers are desirable for this purpose. When mercury thermometers are used, sufficient time should be allowed after the test load is placed upon the turbine to permit the mercury column to come to its final posi-

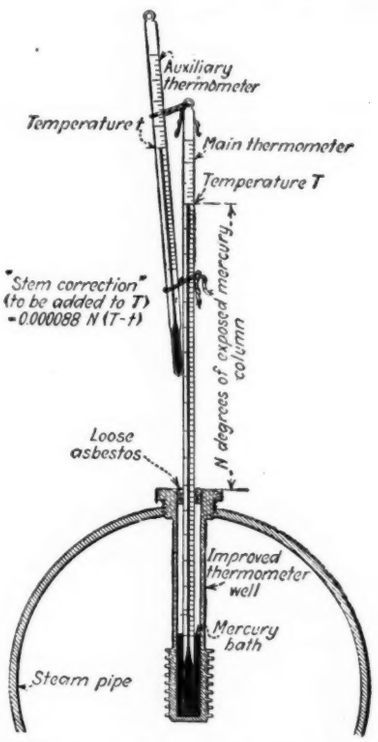


FIG. 3. METHOD OF GETTING STEAM TEMPERATURES

tion. The same precaution must be taken when the load is changed. The thermometer well should be of the latest type and should be placed where it can indicate the true average temperature of the steam. The thermometer used should be checked against some standard. If much of the mercury column is exposed above the top of the thermometer well, a correction should be made for the cooling effect of the air on the exposed mercury. For this purpose an auxiliary thermometer is tied onto the main thermometer so that its bulb comes in the middle of the exposed portion of the mercury column, as shown in Fig. 3. The correction, which is to be *added* in every case, is computed by means of the following formula:

$$\text{Stem correction} = 0.000088\ N\ (T - t)$$

N = Degrees of mercury *exposed;*
T = Temperature of main thermometer;
t = Temperature of auxiliary thermometer.

EDITORIALS

Three Factors in Power-Plant Design

GOOD steam-electric power-plant design embodies three factors: Obtaining a kilowatt-hour with the minimum fuel consumption consistent with cost of fuel and return on investment; reliability; operating convenience. When the point in efficiency is reached where the saving in fuel costs will no longer pay a fair return on the capital investment and other charges necessary to obtain higher economy, the most economical condition has been reached and any further improvement in efficiency only increases the cost of a unit of power delivered to the consumer. This is an important factor, for in the final analysis the consumer's chief interest is how cheaply a reliable service can be obtained and not how efficiently fuel is utilized. Fortunately for the conservation for our fuel resources, minimum cost of power is obtained well up toward the point of maximum efficiency.

Reliability is reflected in the continuity of service and can be obtained by installing a minimum of equipment so well constructed that the possibility of failure is very remote, or a greater amount of less reliable equipment may be used. In past years, when high-pressure, high-temperature steam was beginning to come into use, all kinds of troubles were experienced with steam lines and what is known as loop headers came into general use. This undoubtedly made it possible to get steam to the various units under almost any condition, but not only seriously complicated the piping layout, increased maintenance charges and interfered with the operating convenience, but also materially increased the cost of installation. In spite of the high cost it has been possible in some of the more recent plants, by simplifying the piping layouts, to keep the cost of this element in the construction down to the cost of similar size installations before the war. Welding has reduced the number of joints in each section of header to a minimum; improved methods of making up the joint between sections have practically eliminated trouble from this source, so that the single header, when properly designed and installed, possesses as high a degree of reliability as the old loop header and lacks all its inconveniences. In many other features of the plant improved design and construction has made it possible to discard practices considered in the past essential to reliability.

Efficiency and reliability are factors in power-plant design on which attention has been centered for years, but it is comparatively recently that operating conveniences have received serious attention. It may require from one to two years to design and construct a plant, but its operation may continue for twenty or thirty years or even longer. Consequently, operating convenience should rank in importance with economy and continuity of service. In one sense probably it is of more importance, since if the plant is convenient to operate, the possibilities of its being kept in a high state of maintenance are greater, which will add to both the economy and the reliability. In the leading article in this issue is described the South Meadow plant of the Hartford Electric Light Company. This station, in economy and reliability, no doubt, compares favorably with other modern stations, but in simplicity of design and arrangement it has operating-convenience features that mark an advance in power-plant design. Natural lighting in the firing aisle and in the turbine-room basement has in the past been practically unknown in power plants, but is an actuality in the South Meadow Station. The concentration of all boiler-room auxiliaries on the boiler-room side of the condenser floor places all this equipment where it can be readily looked after by one group of attendants. There has been a tendency for some time toward the centralizing of boiler-room control, but no great progress has been made except in concentrating the control of each boiler. Centralizing the control of operation of all boilers in one room in the South Meadow Station will undoubtedly be watched with much interest by power-plant designing engineers, with the possibilities in view of doing in the boiler plant what has been done on the electrical side of the plant; that is centralizing the control.

Benevolent Despotism or Industrial Democracy?

WHILE the leaders of the world's thought are in conference at Washington in an endeavor to mitigate or do away with war between nations, there comes a voice crying in the wilderness for the killing of the war spirit in industry.

B. Seebohm Rowntree, director of Rowntree & Co., Cocoa Manufacturers, of York, England, is one of the industrials who has seen the light. The doctrine that he is preaching would, if universally applied, go far toward converting the present system from a more or less benevolent despotism to an industrial democracy.

His five cardinal points are as follows:

1. We must so organize industry that it will become possible to pay all workers of normal ability wages which will at least enable them to live in reasonable comfort.

2. Their working hours must be such as will give them adequate opportunities for recreation and self-expression.

3. Measures must be taken materially to increase their economic security, notably with regard to unemployment.

4. The workers must have a share in determining the conditions under which they shall work; and, finally,

5. They must have a direct interest in the prosperity of the industry in which they are engaged.

Most of these are such as the workman might regard as his obviously natural rights, not needing to be accorded by anybody, but Mr. Rowntree will find many dissenters therefrom among industrial Bourbons and reactionaries in his study of American conditions.

In the attitude of organized labor toward profit sharing there is deeper thinking than the fear that it will

undermine the solidarity of the labor movement or incite the men to a degree of activity and efficiency that will flood the labor market.

Suppose the price of the collective products of labor to be made up as follows:

Overhead	20
Material	40
Labor	40
Cost	100
Profit	10
Selling price	110

of which Labor gets $\frac{40}{110}$, or 36.4, and Capital $\frac{10}{110} = 9.1$ per cent, capital's share being 0.25 that of Labor.

Suppose it is agreed to give Labor one-half of any profit over 20 per cent. With increasing profits Labor's share increases slowly (see table, p. 908). When the profit equaled 100 per cent, his share would have increased from 0.364 to 0.400—but the share of Capital would have increased from 0.091 to 0.300.

How can the returns, the purchasing power, the share of the product, increase to both Capital and Labor? Obviously, at the expense of Materials and Overhead. The man who sells the material gets the same amount of money for it, but the purchasing power of that money is reduced by the increased selling price of the finished product due to the greater profit. The men who mined or grew or prepared or transported or distributed the material have suffered. Material is simply crystallized Labor and it has not been included in the labor of the example.

We must go farther back. Start with the undeveloped mine, the unsown wheat, and the greatest part of the Overhead and Material items of the example given will go into Labor. All that is not as convertible will be interest and rent or royalties. Take these as Interest = 6, Royalties, etc. = 4 and our example becomes

Interest	6	Goes to capital
Rent, royalties	4	Goes to privilege
Labor	90	Goes to labor
Cost	100	
Profits	10	
Selling price	110	

When the profit is 10 per cent, Capital and Privilege get 18 and Labor 82 per cent of the selling price (see table). As the profit increases, the share of Labor (with the same arrangement of receiving one-half of the surplus earnings over 20 per cent) goes steadily downward, while that of Capital and Privilege mount. For a profit of 100 per cent the returns of Labor would have fallen from 82 per cent to 65 per cent and those of Capital increased from 18 per cent to 35 per cent.

Profit sharing may be mildly beneficial to groups, but fails when applied in the broad way to all Labor collectively.

The scale upon which the wage earner can live will be determined by the ratio of his collective wage to the selling price of his collective product. If he can be convinced that the lowering of the costs of production by greater activity and efficiency on his part will result in cheaper and better living for himself by increasing the purchasing power of his wage, the incentive for the "conscientious withdrawal of efficiency," intentional waste, sabotage, etc., will be removed. He wants a fair wage for himself and a selling price for the living that he must buy with that wage, based upon a fair profit to his employer. He is entitled under that arrangement to the same "adequate means for satisfying himself as to the accuracy of the accounts," as is said to be his right by Mr. Rowntree in discussing profit sharing. The average employer would, however, as soon display the intimacies of his wife's toilet as the mysteries of his bookkeeping department; and many a workingman is still to be convinced that increased assiduity and efficiency on his part will not react upon himself and his fellows in a lessened demand for their services and in inflated profits to his employer rather than in reduced selling prices to himself.

Fatuous reasoning, short-sighted and narrow; not to be overcome by the rattling of the industrial sword and class jingoism, but by sitting down together with all the cards upon the table—face up.

A Reliable Short Cut to the Water Rate

THERE are many times when it would be helpful to know the water rate at various loads of the small steam turbines that are found in so many power plants. It is frequently the case, however, that it is not commercially practicable to determine the steam consumption by direct measurements at various loads. There is, therefore, a considerable field of usefulness for a method of testing such turbines that does not require actual measurements of steam consumption. Such a method is presented by Messers. Stansbury and Weil in their article "A Simple Method of Finding Steam Consumption of Small Turbines" on page 895 of this issue of *Power*. Working in the mechanical laboratory of The Johns Hopkins University, and under the general direction of Prof. A. G. Christie, these young men have studied the problem of testing turbines by a method requiring only temperature and pressure measurements. After making a careful theoretical analysis they decided upon a method of testing and then checked the method by several experiments which showed a remarkably close correspondence between theory and practice.

The only measurements required with this method are the pressure and temperature of the inlet and exhaust steam. These quantities are first measured at a known light load, preferably no load. From this preliminary test is computed a constant for the given machine. This constant, used in connection with similar pressure and temperature measurements at any other load permits the accurate determination of the water rate at that load. All of the computations involved are simple and can be quickly made.

In its present state of development the method can be used only where the turbine exhaust is superheated. This condition usually exists, however, with small turbines, providing the steam at the throttle has a fair degree of superheat.

While it seems reasonable to feel that there will be no very noticeable business revival until the spring, a number of different signs are of an immediately encouraging nature. It is reported in the daily press that unemployment has fallen off by about one million and that the situation is no longer acute in some parts of the country. Another welcome note is sounded by the coal mines, which broke the year's production record in the week ended October 22 with a total estimated output of almost eleven million tons of bituminous coal. In the coal business a hand-to-mouth principle prevails, and so if a lot of coal is being mined, a good deal is being used, and we may infer that business is reasonably active.

PRACTICAL IDEAS from PRACTICAL MEN

This Engineer Finds Catalogs of Value

Something that we get gratis and do not seem to appreciate as we should, are the catalogs obtainable from the makers of devices that we use. Years ago I used to stick a stamp on an envelope and send it out with a request for a book that perhaps cost the sender several dollars. And I never even sent a note of thanks when I received the book. I am glad to say that I have got over that, and now I pass a catalog along after I am through with it, to someone who will have a use for it. I also make it a point to let the sender know that I received it, and when I pass it on I let him know where it went. All this costs nothing.

It is surprising how much a man can get out of a catalog, provided he goes about it in the right way. I figure that about 50 per cent of my mechanical education was acquired from catalogs. I have found by practical experience that this business of buying a thing and trying to make it work without intelligent instruction is detrimental to the particular machine and to my standing as an engineer.

To illustrate this point: In the plant where I am employed, we bought CO_2 recorders of a well-known make. The instruction books were lost in shipment, and owing to the stress of other matters none were ever sent for. In time we set up the machines and none of them would work. We wrote to the maker and he sent a representative of the company to the plant, who told us that we had not piped the machines up right. For two months we ran these machines without getting a correct reading, and then I took the liberty, against my superior's orders, to send for instructions relative to the machines. I received a letter containing some mighty good advice. I also received catalogs and other literature that simplified my work with these machines.

Today we have readings that are correct. When I go to a machine and find it out of adjustment, I know exactly what to do without any experiments. All I have to do when a new trouble develops is to look it up in my catalog.

We can store a certain amount of information in our brains, but there comes a day when there is no more room, and from that day if we persist in trying to make our brains store more knowledge we slip back. Why should an engineer try to store in his brain all the details of the business of engineering when there are so many good books and descriptive matter relative to all branches of the business, many of which can be had for the asking? I make a study of the index of my book and know where to look for information without cluttering up my brain with it until I want it.

Years ago I used to send for catalogs irrespective of whether they had a value to me. I know now that this is unjust to the givers of catalogs, and when I send for one I try to see that some business is sent back in return. I make no pretense of keeping or filing catalogs, as they would soon run me out of house and home, but have a little system that I think is worth while.

Each device in my plant is listed in a loose-leaf book. From each manufacturer of the equipment we use I secure all the literature relative to their productions that they can give me. That literature I list in my book so that I can find in an instant any catalog or booklet in my files. In my spare time I take a new catalog and carefully go over all the instructions given, note all the construction details, the faults and the remedies, and all the details of operation. All this I separate from the general reading matter and rewrite and file in my book. In other words, I eliminate the selling end and make the reading nothing but pure instruction. With this system I have every device in my plant so written up that a stranger could handle my job with ease.

When a device goes bad, I look over my data book, find the trouble and adjust the matter as advised in the book, and in ninety-nine cases out of one hundred that ends the trouble. I do no experimenting with my machinery. One of my firemen once told me that I carried my brains around in a book, and perhaps I do, but I manage to get by.

A. D. PALMER.

Fall River, Mass.

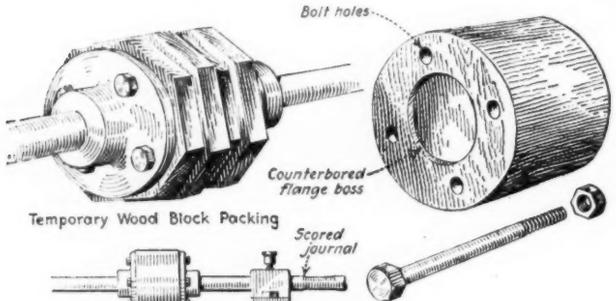
Lengthening Shaft at Coupling

Sometimes a lineshaft requires lengthening a few inches, and if there is a flange coupling in the line this is easily accomplished by fitting hardwood distance pieces between the flanges and using longer coupling bolts. In some cases the shaft journal might be scored, and by extending it a few inches a new surface is obtained to run in the bearing.

A temporary distance piece may be quickly made up by sawing off the corners of square wooden blocks or pieces of board, making them roughly octagonal as shown in the illustration. These are placed together

with the grains crossing, clamped between the coupling flanges and the bolt holes drilled and the bolts put through and tightened up.

A permanent blocking is made by turning up a piece of well-seasoned oak or other hardwood to the same diameter as the flanges, or a little larger if there is



KIND AND APPLICATION OF SHAFT BLOCKING

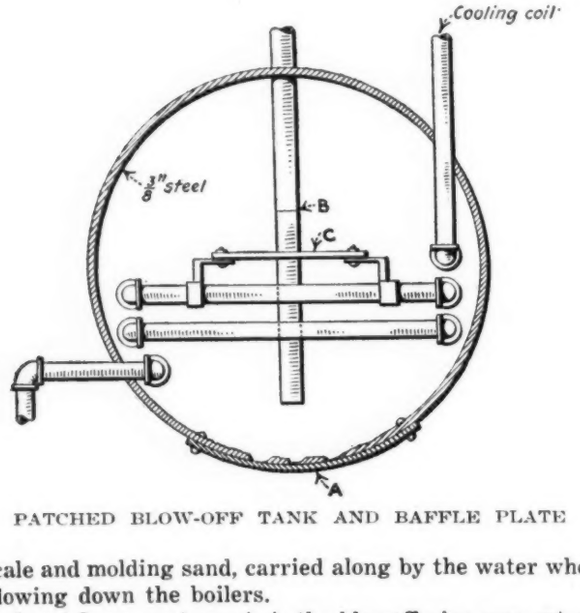
room; it is counterbored for the flange boss if there is one, the bolt holes drilled and the whole piece soaked in oil or other preservative before being set in place.

Oakland, Cal. P. H. HARRIS.

Erosion of Blowoff Tank

In a steam plant in New York, using Croton water for boiler feed, after being in service two years the blowoff tank was found to be eaten through the shell at a point directly under the end of the blowoff pipe, which extended down inside the tank to within 8 in. of the shell.

On examination the pitting seemed to have the characteristics of electrolysis, but it was finally decided that the damage was caused by the sharp impact of boiler



PATCHED BLOW-OFF TANK AND BAFFLE PLATE

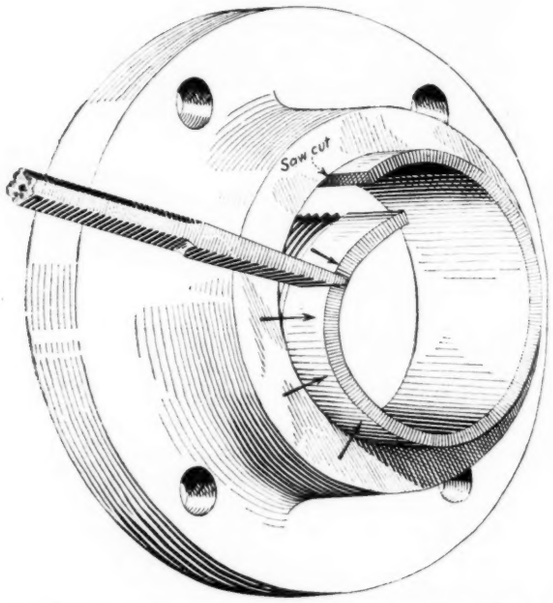
scale and molding sand, carried along by the water when blowing down the boilers.

A patch was put on at *A*, the blowoff pipe was cut off as shown at *B*, and a case-hardened steel baffle plate *C* was secured by straps to the cooling coil. Frequent inspection, later, failed to disclose any erosion of the baffle plate. M. M. BROWN.

Camden, Me.

Removing Rusted Pipe from Flange Coupling

Sometimes an iron pipe, as in the case of a gas-engine exhaust pipe, becomes so rusted into the flange coupling that it cannot be removed. In order not to destroy the flange, the pipe can be sawed off about half an inch from the coupling, then a hacksaw cut made through



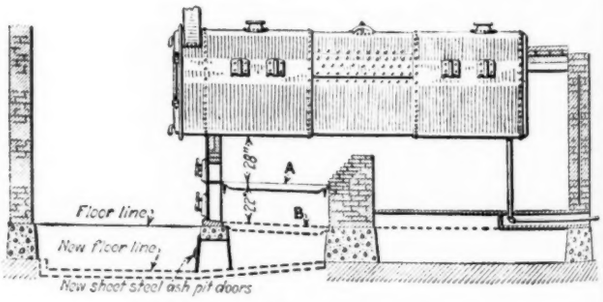
REMOVING RUSTED PIPE FROM FLANGE COUPLING

the stub end, lengthwise. A cold chisel is then applied to the outside of the projecting end, at the cut, and by gradually working around the pipe it can be loosened from the threads in the flange, curled up, as shown and removed without injuring the threads of the coupling.

Oakland, Cal. H. H. PORTER.

Increasing the Distance from Grate to Boiler

Some time ago I took charge of a small plant where two 72-in. x 18-ft. horizontal-tubular boilers were in use. These boilers had been furnished with standard full flush fronts with the grate bars just 28 in. from the boiler shell. The management were always com-



INCREASING FURNACE HEIGHT

plaining of the excessive amount of coal used and were about ready to shut down the plant and purchase central-station service. This was explained to me when I took the position, consequently I set to work to learn how I could reduce the coal bill, which I could see was

out of proportion to the power used in the mill. In the first place a high grade of anthracite steam coal was burned; the fireman and former engineer claimed that the boilers wouldn't steam with buckwheat coal.

As a first step I purchased a low-priced flue-gas analyzer and found that we were getting only 5 per cent of CO_2 and considerable CO. I felt that the chief trouble lay in the small furnace height, which prevented complete combustion, so I tried to persuade the owners to reset the boilers and increase the distance from grate to boiler to 54 in. This they were unwilling to do since it meant an outlay of about seven hundred dollars. As a last resort, to show them that the coal saved would justify the expense, I tore out the grate bars in one boiler on a Sunday and dug a pit two feet deep below the ashpit and a trench to the front of the boiler. The grate bars were placed in the ashpit on a level with the bottom of the doors. This took a lot of hard work, but when completed we had a furnace that was 50 in. high instead of 28 in. On Monday the boiler carried the load with ease and the coal consumed was one-third less than before, although the water evaporated was, as near as we could figure, about the same as usual.

The CO_2 reading ran up to 9 per cent, and I felt that my contention as to a larger furnace height was proved. The owners were notified of the improved condition, and the suggestion was advanced to them that both boilers should be reset to bring the ashpit doors above the floor level. The coal saving more than justified it, but the owners were disinclined to spend the money. We then removed the brick floor in front of the boilers and by removing two feet of dirt lowered the floor line to the level as shown in the illustration. The second boiler was treated as was the first one. J. CASSIDAY.

Jersey City, N. J.

A "One Night Stand" as Chief Engineer

Looking back on the time when I got my first job in a power plant, I find many a chuckle in remembering the troubles and narrow escapes that I had. The job didn't last very long; in fact it was what the actor would call a "one night stand." I was sorely in need of work and late in the afternoon dropped in at a little shingle sawmill in British Columbia. I met the owner, proprietor, chief engineer and personnel manager, these being one man. His duties had always been exacting, but for the last few days he had been working day and night because his night engineer had quit, and he was dead on his feet for want of sleep. A Zulu Islander would have been given the job and would have known hardly less about it that did I. I was honest enough to say that I wasn't really an engineer, but my new employer said he would make one of me, and he certainly made a good start. He took me over the plant, showed me the boilers, the engine (of about 100 hp., as I recall), the boiler-feed pump, the injector, the throttle valve, the gage glasses and considerable other paraphernalia, none of which made a very lasting impression on me.

When it came time for the night shift to start, the boss helped me to throw firewood into the furnace to get up steam, opened up the throttle for me, gave me a few hurried words of caution, and disappeared. The prospect was interesting, and certainly I have seldom spent a more entertaining evening.

I had a fairly well-defined idea that the water level in the gage glasses should be kept somewhere in sight, and so I tried my best to keep it there by manipulation of various valves that had been pointed out to me on the injector and feed pump. Unfortunately, however, the pipes ran around behind the boilers, so that, if one should forget which valve controlled a particular boiler, he would be likely to put water into the wrong boiler—and I did forget. It didn't seem to make very much difference which valve I opened, nor whether I used the injector or the feed pump. The level in one boiler rose little by little, while that in the other gradually fell.

But there was little time for worrying. I soon found out that running the engine and tending the boilers was only a small part of the job. The big part was to carry shingle-bolts for two ambitious young chaps engaged on piece-work. A shingle-bolt is a section of a tree trunk and is as long as the finished shingle, with a diameter of 2 ft. or more. While an able-bodied man would find no difficulty in lifting one of these off the floor, it was an entirely different matter to carry them across the room as fast as the two lads on the saws could turn them into shingles. It was splendid exercise!

The furnaces were fed with waste from the saws, this being not only sawdust, but large and small sticks of wood and imperfect shingles. This material slid down a chute through a hole and into the furnace. That is, it did so when the hole was not clogged up with awkward-shaped pieces. At various times, and they were frequent, it was up to me to run downstairs and ram the stuff through the hole into the fire. This helped to relieve the monotony, anyway.

Every now and then the whistle would toot, which meant that I was to slow down the engine. There were no halfway measures about my work, and so in slowing down I went all the way. As far as I was concerned, that engine had just two speeds, one the normal operating speed and the other a standstill. I couldn't make it run at any other.

At one of these times the engine stopped at dead center. I was equal to the occasion, however, found a rod handy and barred the wheel over a little way. Being in somewhat of a hurry, I left the bar between the spokes and opened the throttle. To my surprise the engine started, although the bar gave me a bad scare when it started up in the air and dropped beside the flywheel. However, things that might have happened were among the least of my worries.

For instance, there was the water level. As the night wore on, the condition got worse, no matter which valve I turned on, and when the "morning after" finally broke, there was about half an inch of water in one gage glass and the level in the other glass was about that far from the top. To this day I don't know what the trouble was, but what really puzzles me is, What would have happened first if I had had charge for about an hour longer? Would one of the boilers have gone up, or would the engine have taken water and blown its head off? Perhaps both would have happened.

Whether I would have wrecked the plant or not on the following night I cannot tell, because during the day a man who had actually run engines before came along, and I was told, with admirable courtesy, that I didn't have quite enough experience to handle the job.

Seattle, Wash. R. M. DENNISON.

[Do you ever hark back in memory to your first power-plant job and laugh at the things that happened to you, as Mr. Dennison does? Doubtless there are many others whose early experiences were as laughable as his, and would make interesting reading.—Editor.

CORRESPONDENCE

Advantage of Nitrogen in the Boiler Furnace

An article under the title of "Advantage of Nitrogen in the Boiler Furnace" appeared in *Power* of Oct. 25, which is likely to produce a wrong impression among engineers concerning certain phases of combustion and heat absorption.

To be specific, the first and the last sentence in the article are not in accord unless it were assumed that power engineers would try to use the same kind of boiler settings with oxygen as are now in use for the dilute mixture of oxygen with nitrogen. Such would never be the case, however.

Boilers and furnaces would both be redesigned and the resulting effect would be a great increase in efficiency, because the weight of stack gases per pound of carbon (with perfect combustion) would be reduced from 11.54 to 3.67 and the stack loss reduced in the same proportion if the stack temperature remained the same. As a matter of fact the stack temperature would be much lower even with the same boiler-heating surface, because (a) more heat would be absorbed by the boiler in the radiant form and less would remain to be absorbed by convection, and (b) the same rate of heat transfer could be obtained by reducing the area of the gas passages to maintain the same velocity, and the same heating surface would allow the gas travel to be increased to three times that allowable with present practice.

A simple analogy is found when it is remembered that the ideal of all combustion engineers is to reduce the quantity of excess air (raise the CO_2). As far as the effect on heat transmission is concerned, both the nitrogen and the oxygen in the excess air are thieves and produce the same result as the nitrogen of the required air. They are thieves which steal heat from the process of combustion, and while much of it is recovered by the boilers, from 10 to 15 per cent is carried out the stack as their loot.

Temperatures above those which materials now available can stand, do not need to be permitted. The quantity of radiant heat absorbed by the boiler will increase rapidly with any rise in temperature. According to the Law of Stefan and Bollzmann[1] it varies as the fourth power of the absolute temperature. At 3,500 deg. F. (almost 4,000 deg. abs.) each square foot of hot surface gives off 360,000 B.t.u. per hour as radiant heat. It would be perfectly practical to have a temperature of twice that figure in the combustion zone by providing sufficient space around the zone between the high-temperature region and any material that might be damaged. At that temperature almost 500,000 B.t.u. would be radiated to the boiler from each square foot of radiating surface.

By constructing a boiler setting with more absorption surface exposed to radiant heat and having little or no refractory material present, the temperature of the furnace would be kept down easily. If some diluting medium were necessary, then a part of the stack gases would be used so as to save that much heat.

One other fundamental factor is also important. The temperature of the steel tubes forming the boiler-heating surface is always within a very few degrees of the water temperature within the boiler. A rapid calculation indicates that a boiler can be operated at one thousand per cent of rating (it has been done), and the temperature of the outside of the tube will not be more than fifty degrees higher than the water temperature; and if the tube is clean on the water side, there may be only twenty degrees difference. Adding fifty degrees to the temperature corresponding to 350 lb. per sq.in. gage still leaves a nice margin of safety below the danger temperature. In fact steel is usually stronger at that temperature than at 70 deg. F.

Another disadvantage that must be put up with when nitrogen is used, is the slowing up of combustion, both by keeping down the temperature and by being a barrier which prevents the oxygen from getting together with the carbon. A greater amount of excess oxygen to combine completely with all the carbon must be used when nitrogen is present.

Boilers could be built with smaller furnaces, and less heating surface would be required to obtain the same capacity and efficiency. So why worry about something that could not happen? The real worry is that for the time being at least we are forced to feed the furnaces that thieving nitrogen along with oxygen.

Summing up the foregoing, it will be found that nitrogen is harmful because (1) it reduces the efficiency by carrying heat away in the stack; (2) it is not needed to prevent damage to the boilers, as better methods are available; (3) it requires larger furnaces to accomplish the same completeness of combustion; (4) it requires more heating surface (larger boilers) to accomplish a given amount of work.

Perhaps there are still other reasons, but these should be sufficient to illustrate the major principles involved.

J. C. HOBBS.

Pittsburgh, Pa.

[1]See Bulletin No. 2, Bureau of Standards, 1905, by Warder and Burgess. Also Bureau of Mines Bulletin No. 18, "Transmission of Heat Into Steam Boilers," by Kresinger and Ray, 1912.

Exciter Failed to Generate

I read Mr. Baxter's article, "Exciter Failed to Generate," in the Nov. 1 issue of *Power* with much interest. It brings to mind an argument that I had, in which my friend claimed that the 5-kw. exciter would not build up until he reversed the direction of the current through the series field. On examining the connections, they were found as shown in Fig. 1, in which both shunt-

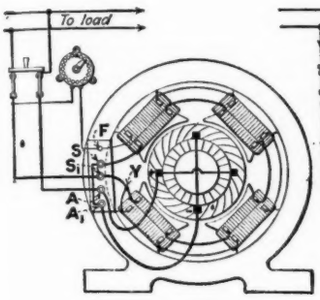


FIG. 1. INCORRECT CONNECTIONS

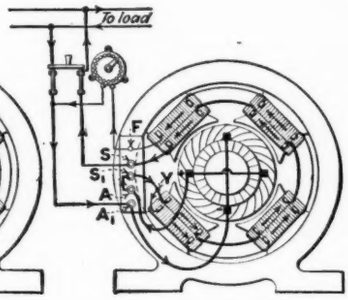


FIG. 2. CORRECT CONNECTIONS

field leads were tapped on to the same wire, as indicated at *Y* and the left-hand side of the switch. When the series-field leads were supposed to have been reversed, the shunt-field leads were connected across the line, as shown in Fig. 2. But in this case, instead of the series-field leads being reversed, they have been interchanged with the armature connections, as will be found by comparing Fig. 1 with Fig. 2.

In nine cases out of every ten, when a generator is wired up or has been moved from one locality to another and fails to generate, I find it is because the shunt field is not connected across the line or the shunt-field lead needs to be interchanged to produce the correct relation between these connections and the armature.

I agree with the editor that the series field connected in opposition to the shunt field would not prevent the generator from building up its voltage. It might fail to generate if the exciter was considerably over-compounded and started up with its switch closed, thus connecting the machine to the load. The 5-kw. 125-volt exciter that I mention is flat-compounded and will start up, with the switch closed connecting it to the load, with the series and shunt fields opposing each other, and generate 55 volts. MARIN PHILLIPS.

South Kaukauna, Wis.

Electrical Faults That Were Difficult To Locate

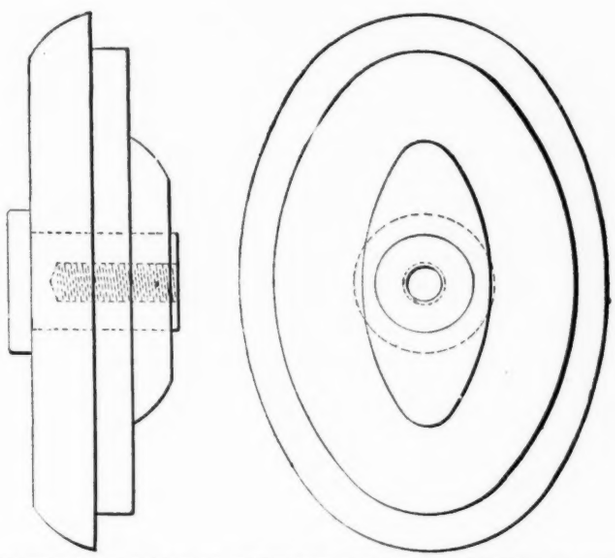
The editorial "Locating Electrical Troubles" in the Nov. 15 issue of *Power*, wherein it is stated that some electrical faults are difficult to locate, brings to mind an experience that extended over a period of about one year before the real cause of the trouble was discovered. A rotary converter that was arranged to be started from the direct-current side would every once in a while blow its fuses, sometimes at the instant of closing the switches for starting and at other times when the machine was running. After each time the fuses blew, tests were made for both grounds and short-circuits, but no indication of the fault could be obtained. Even a test for insulation resistance to ground showed that this resistance amounted to about 3,000,000 ohms, which indicated that the insulation of the equipment and wiring was in good condition. Almost everything conceivable was tried, even to insulating the frame of the machine from ground, but to no avail; the fuses would blow at intervals of a week or so. This went on for about a year, when one day the fuses blew and the cause of the trouble remained. It was found that the fault had been started by a splice on one of the conductors running through the conduit from the switchboard to the machine. Probably the fault was first started by a sharp point on the splice working through the insulation, as the conductor was caused to vibrate against the side of the conduit. When the first short-circuit to ground occurred, the metal-to-metal contact was burned clear, but left the insulation between conductors in bad shape. The current leaks between conductors and to ground after this reduced the insulation to a point where short-circuits occurred and each time clearing the defect for the time being.

One of the unfortunate features of such experiences is that little is to be gained from them, since two such troubles rarely occur under similar conditions, therefore the experience of one is of little or no use in the other.

Boston, Mass. CHARLES A. ARMSTRONG.

Protecting Handhole Bolts and Gaskets from Burning

A correspondent in the Oct. 11 issue of *Power* wants to know how to keep handhole bolts and gaskets from burning. The gaskets, of course, will not burn if there is water in the boiler. The sketch shows our method of preventing the threaded parts from burning



HANDHOLE BOLT IS SCREWED INTO HANDHOLE PLATE

by placing them where they are kept comparatively cool by the water; that is, screwing the bolt into the handhole plate.

Of course the bolt and crab will finally be destroyed by the heat, but if the threads are smeared with graphite and oil they will always work freely. I have had four boilers equipped thus for seventeen years and find it quite satisfactory. J. O. BENEFIEL.

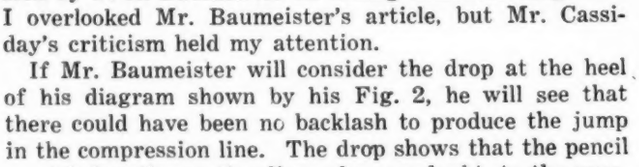
Anderson, Ind.

Taking Indicator Diagrams

In *Power* of Oct. 25, J. Cassiday criticizes a discussion by P. A. Baumeister on taking indicator diagrams. I overlooked Mr. Baumeister's article, but Mr. Cassiday's criticism held my attention.

If Mr. Baumeister will consider the drop at the heel of his diagram shown by his Fig. 2, he will see that there could have been no backlash to produce the jump in the compression line. The drop shows that the pencil went below the suction line—due, no doubt, to the pressure necessary to open the inlet valves—and rose again on being pushed up by the piston, thus removing the backlash. Mr. Cassiday's explanation appears to be the correct one for the distortion in this diagram.

The distortion in the other diagram, Mr. Baumeister's Fig. 4, could, in my opinion, have been caused by the use of a pantograph reducing motion with loose joints. A weak drum spring, if the diagram is from the crank



WHAT IS YOUR CRITICISM OF THIS DIAGRAM?

end, could cause the distortion at the point marked by Mr. Baumeister, "Indicator drum lagging," but could not cause the re-expansion line to fall to the right of the probable re-expansion line, as that would necessitate stretching the cord and drum springs do not do that.

If the diagram is from the head end, an obstruction in or about the drum or in the reducing motion might cause the lag at the point referred to, by stretching the cord, but after the obstruction is passed, the drum would recover and the pencil would trace the "probable re-expansion line." Mr. Cassiday's contention that a stretching cord would throw the re-expansion line to the left and not to the right is correct for a head-end diagram, and the cord is not likely to stretch on a crank-end compressor diagram.

Mr. Cassiday has misunderstood which spring Mr. Baumeister refers to as causing the lag. The reference is clearly to the drum spring.

The accompanying compressor diagram is offered for criticism. R. McLAREN.

Toronto, Ont., Canada.

Valves on the Water-Column Connections

On page 733 of the Nov. 8 issue R. B. Arrell has an article on water columns to which I wish to make a few comments. He seems to think that valves are a good thing on the water column. If we look at it from the viewpoint of shutdowns and not public safety, they would be called very handy. My objection to them is that they can be closed by anyone by breaking the seal, which can be done without much trouble.

An incident occurred in my plant a short time ago. The night watchman called me up early in the morning and said that he could not get any water in the boiler. I told him to bank the fire and that I would be down. Upon arriving, I found that through some excitement he had closed the bottom valve, and the water could not get into the water glass. Of course steam showed in the glass and try cocks at all testings. Therefore I am not in favor of valves in the water-column connections. F. C. EASTON.

Springfield, Mass.

Opening and Closing Blowoff Valves

A number of opinions have doubtless been changed lately regarding the subject of opening and closing blowoff valves, but the explanation on page 537 of the Oct. 4 issue, by Burton Wheeler is, according to my experience, an important one, and I take the liberty of giving my point of view of this subject.

Water hammer in blowoff lines has resulted in some accidents, and it is for this reason that the Hartford Steam Boiler Inspection and Insurance Co. in paragraph No. 10, under the heading, "Routine Use of the Blowoff," gives the following rule:

> To remove sediment from the bottom of the boilers, open the blowoff valve in the morning, or before the circulation has started up. The valve should be open wide for a few moments, but it should be opened and closed slowly, so as to avoid shocks from water-hammer action.

According to my experience the best blowoff arrangement that can be used is a stop cock next to the boiler and an angle valve at the end. In case an angle valve cannot be used, an extra-heavy gate valve with solid wedge should be employed. In blowing off the boilers, we proceed as follows: First, slowly open the stop cock, then open the angle valve; after the blowing down has been finished, the angle valve is slowly closed and then the stop cock.

The argument brought up by users of stop cocks, that it is not advisable to have these next to the boilers because the plug has to be turned in the scale lodged around it, is more or less out of place, because the plug is made of one substantial piece and is protected all around.

It is seldom that a stop cock used in a liquid containing dirt, scale or sediment cannot be closed after using, as the sharp edges of the hole in the plug will cut off these substances. However, this is not the case when a globe or gate valve is used, as the inability to close valves occurs when they have to be lifted from their seat and this results in delay and other unpleasant features. Placing the angle valve outside the stop cock prolongs its life, because it is easier to grind in a stop cock than it is to overhaul an angle or gate valve while in place.

Trouble with sticking of the stop cock depends, in many cases, upon the make; however, in our plant, by the use of balanced stop cocks for blowoffs, the trouble of sticking is removed. The construction of this stop cock is such that sticking, which is caused by the plug becoming warm first and fitting tightly into the body for a moment, will be reduced as soon as the temperature of the body reaches the temperature of the plug, at which time the latter turns so easily that a small wrench can be used to move it.

Another advantage of this valve is that the plug can be rotated through 360 deg., consequently the wear resulting from the operation of the valve and from regrinding is evenly distributed over the whole of the bearing surface. F. C. HEYLMAN.

Martinez, Cal.

Investigation of Turbine Breakdown

The article in the Nov. 22 issue, dealing with the investigation of the breakdown of a 30,000-kw. turbine is extremely interesting to me and recalls a peculiar trouble experienced some seven or eight years ago on two 750-kw. straight impulse low-pressure turbo-generating units operating at 2,200 r.p.m., using exhaust steam, mainly from a rolling-mill engine.

I put both of these machines through a test at the manufacturer's works. The steam used in the test was high-pressure from the testing boilers, and reduced to 1½ lb. gage by a reducing valve placed close to the test bed, which meant that dry steam was used. During the test of both of these machines I, being sensitive to vibration because of extensive practice at this class of work, noticed what might be termed a subconscious vibration, in other words, a different type of vibration from that found in high-speed work. This was noticeable exactly at full load, which was the maximum of steam available from the test boilers, but no sign of touching could be detected and on examination everything seemed in order.

After a discussion of this peculiar trouble it was decided that I should see these machines through their test on the site, as the other engineers of the manufacturer could not distinguish this peculiar vibration.

These machines were installed and given their preliminary run without any trouble until put onto the water-rheostat test for capacity. At about 5 or 4 per cent under full load, I detected, by using a listening stick, a faint touching and at once reduced the load, when it disappeared. On increasing the load again, the faint metallic noise at once became audible. This was repeated several times with the same results in each case, and it was decided to open up the machine. The load test on the other machine was at once proceeded with and exactly the same results developed at 1 to 1½ per cent of the same load, and at once this machine was also opened up. Examination showed that the corresponding intermediate wheel in each machine, at practically the same load had become distorted and had touched the diaphragms on either side of it.

The diaphragms showed faint scratching all round, but the disc showed rubbing marks on both sides in alternative places, proving that the wheel was being distorted. At the time I decided that the trouble was due to the rhythmical vibration of the disc synchronizing with the normal 2,200 r.p.m. of the rotor, this vibration becoming intensified as the weight of the steam passing through the blades increased with the load. The obvious remedy was to increase the thickness of the disc. This was done and, in addition, the initial nozzles of the machine were more evenly placed. Since these changes the machines have run with satisfaction.

The interesting point is the exact conditions under which this trouble could be controlled, both machines being of the same design and operating under the same steam pressure, load and speed.

One thing I would bring to notice is that had ordinary saturated exhaust steam been used or a larger quantity of dry steam been available on the test bed, the trouble would have been found there. I have had two other experiences from unknown causes which pointed strongly to this distortion of the disc. The trouble in finding the reason of breakdowns is to distinguish between cause and result, and from defects developed on the disc type of machine, it is quite evident that strains and stresses are set up under certain conditions which turbine builders are not yet thoroughly conversant with.

Perhaps those interested in the investigation of the Schuylkill plant may find something of profit in the foregoing.

R. J. McLEAN.

Montreal, Canada.

Engineer or Engineman

I read with interest what E. L. Jessup had to say regarding the status of "Engineer or Engineman," on page 651 of the Oct. 25 issue. I think his idea pretty nearly covers the question. I was recently employed as watch engineer in a 2,500-kw. central station under a chief engineer whose "wise stunts" were a joke. If the watch engineer offered a suggestion in the way of improving things, he was made to feel cheap.

One night about 12 o'clock the forced-draft fan went out of commission. At the same time the roof-tank pump broke a valve-stem yoke. This pump was at the foot of the hill on the bank of a lake. From the roof tank the water went to the boiler-feed pumps, through the heater by gravity feed. The chief had given orders that in case of any trouble he should be called. So I called him.

He found me working on the pump, and the fireman and his helper were working on the fan engine. This chief is an old-timer, very nervous and easily rattled. The new electric pump at the lake would not pick up water, so we were in a hole and getting worse every minute. Steam was at 60 instead of about 170 lb., which was normal. The chief began to rip and rave, called everybody names and then some. During the circus he closed the suction valve to the steam pump and finally we succeeded in getting her ready to run. Then he rushed up to the pumproom to find out why the boiler-feed pumps got no water. It never occurred to him to look at the heater glass and see that it was empty.

After an hour and a half he "hot-footed" down to the lake and by mere accident found that the pump suction valve was closed. Of course as soon as that was opened we had water. As long as there was no water, the pump lost its sealing water and consequently no vacuum could be formed. During the circus all the water we got was from the hotwell of the turbine.

Next the chief asked me why I closed that suction valve, and when I told him that he had closed it himself (the coal wheeler also was among those present) he went to pieces again, and as a result I left that morning.

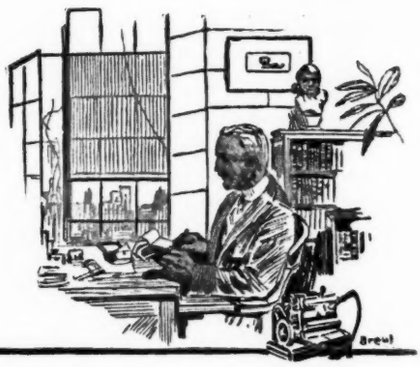
One day previous to this I had "phone" orders to cut out the local street-railroad wires for making repairs. The chief came in from lunch, saw the oil switch open and put it in. Just his luck no one was killed.

I think that this recital of incidents goes to prove that even a chief engineer (who holds a first-class license from New York City, as this man does) can go wrong and cause considerable unnecessary trouble. Nearly all my life I have been running one-man plants. A man in such a plant will, from force of habit, think several times before he makes a move. Moreover, he will have the brains and ability to handle all machinery under his charge and often some that is not. He is, to my mind, more of an engineer than the man whose pants shine in the rear and who has his name with C.E. on the office door.

R. G. SUMMERS.

Syracuse, N. Y.

QUESTIONS AND ANSWERS



Lengthening Stroke on Duplex Pump

How is the length of stroke increased on a duplex pump? R. F.

The steam valve of one side of the pump receives its motion from the piston rod of the other side, and the length of stroke of one side will be prolonged by delaying admission of steam to the other side. Hence, to lengthen the stroke on either corner of the pump, increase the lost motion of the steam valve on the opposite side and at that end of the lost motion which is in contact when the stroke that should be lengthened is completed.

Size for Governor Driving Pulley

How can it be known what diameter of throttling-governor driving pulley to place on an engine shaft for obtaining a given number of revolutions per minute of the engine? A. R. B.

A throttling governor usually is furnished with a receiving pulley, and the manufacturer supplies information of how fast the governor is to be driven. The r.p.m. usually is stamped on the governor. Knowing the speed and diameter of the receiving pulley, the diameter of governor driving pulley that should go on the engine shaft is found by multiplying the diameter of governor receiving pulley by the proper r.p.m. and dividing the product by the r.p.m. desired for the engine.

Breakage of Connecting-Rod Wedge Bolts

What causes breakage of wedge bolts that hold connecting-rod crank-pin brasses? G. B.

Any form of draft bolt for holding the wedge to place is likely to become cracked and broken from shocks received by the brasses from the connecting rod and transmitted by the wedge to the bolt. The trouble is made worse from pounding, as when the halves of the brasses are tight together, but there is too much room for the crankpin when the wedge is set up tight; or when the brasses are not brought tight together by the setting of the wedge. In the latter case there will be a tendency of rocking motion in the brass combined with more or less pounding and these, assisted by the tendency of the wedge to back out, cause enormous stresses from impacts that eventually result in cracking and complete fracture of the bolt.

Heavy-Duty Engine

What is the difference in design of a "heavy-duty" and a "Tangye-frame" engine? A. T. B.

Generally speaking, engines that are especially designed to withstand shocks and to carry extraordinary loads in proportion to their size are designated "heavy-duty" engines, regardless of the form of frame or bed, although the designs of most engines coming under the designation of "heavy-duty" have their beds or frames supported on their foundations for the full distance from the cylinder to the main bearing, in that respect resembling the Tangye bed.

The Tangye bed or frame is a single casting ogee in form of plan, resting for its full length on the foundation, with the cylinder overhung at one end and the main bearing in the other end. An ogee form of bed supported for full length by the foundation when used with a cylinder that rests on the foundation, in place of overhanging, is frequently designated a Tangye form of bed, and the bed may be a single casting or built up in sections. The Tangye form is often used in designing engines for ordinary service, and on account of the adaptability of this form to designs of great strength and rigidity it is commonly but not exclusively employed for "heavy-duty" engines.

Equalize Leads Rather Than Cutoffs

Is it preferable to set an ordinary D slide valve with equal leads, or equal cutoffs? F. E. B.

On general principles it is better to set a given slide valve for equal leads than equal cutoffs. With most proportions of valve gear, the greater length of cutoff in the head end of the cylinder, due to angularity of the connecting rod, makes little difference in economy of expansion. To move the valve on the stem toward the head end, to obtain equalization of cutoffs, not only causes later admission, earlier release and later compression on the head end, but also results in earlier admission, later release and earlier compression of the crank end. The later lead and less compression on the head end are likely to produce pounding, and the excessive compression on the crank end, together with lessening of compression on the head end, usually will have little if any effect in better equalization of mean effective pressure in opposite ends of the cylinder.

However, there is no objection to setting the valve to compromise the leads, cutoffs and compression within limits of smooth running of the engine.

Submergence and Air Pressure for Air-Lift Pump

In a 6-in. well that is 85 ft. deep the water stands 14 ft. below the surface of the ground. For raising the water with an air lift, how deep would it be necessary to put down the air pipe and what air pressure would be required? J. V. S.

Under average conditions the best results are obtained when the submergence is about 60 per cent of the air lift; that is, about 1½ times the net lift of the

water, measured from the working level of water outside of the well discharge pipe up to the level of the discharge. For instance, if the level for discharge of the water is to take place 4 ft. above the ground and the working water level drops to 20 ft. below the ground, requiring a net water lift of 24 ft., then, when running, the air pipe should be submerged $1\frac{1}{2} \times (20 + 4) =$ 36 ft., thus making the air lift equal $36 + 20 + 4 =$ 60 ft. The drop from the standing water level to the level when pumping depends on the rate of underground flow to the well and rate of pumping. These generally are not known in advance, and after providing for an assumed drop, the submergence should be altered by raising or lowering the pipe until the best rates of discharge are established.

The air pressure required does not depend on the total air lift, but upon the amount of submergence. Hence higher air pressure will be required when the pump is being started than when at work. In either case, for overcoming pressure due to submergence and other resistances, the gage pressure required for the air will be about 0.45 times the depth of submergence in feet.

Pitch of Staybolts

What should be the pitch of riveted screwed staybolts for staying a flat surface of $\frac{7}{16}$-in. firebox steel plate, of 55,000 lb. tensile strength, to carrying a safe working pressure of 160 lb. per sq.in.? C. J. K.

The maximum allowable working pressure for various thicknesses of braced and stayed flat plates with stay bolts of uniform diameter symmetrically spaced is calculated by the formula:

$$P = C \times \frac{T^2}{p^2}$$

where

P = maximum allowable working pressure in pounds per square inch.

T = thickness of plate in sixteenths of an inch.

p = maximum pitch, measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined, in inches.

C = 112 for stays screwed through plates under $\frac{7}{16}$ in. thick and 120 when over $\frac{7}{16}$ in. thick, with the ends of staybolts riveted over.

As in the question we would have $P = 160$, $C = 120$ and $T^2 = 9 \times 9$, or 81, by substituting these values in the formula it becomes

$$160 = \frac{120 \times 81}{p^2}$$

Hence $160\ p^2 = 120 \times 81$; $p^2 = \frac{120 \times 81}{160} = 60.75$; and $p = \sqrt{60.75} = 7.79$, or practically $7\frac{3}{4}$ in.

Time Required To Fill Tank with Compressed Air

How long will be required to fill a closed tank of 8,000 gal. capacity with air compressed at 50 lb. gage pressure, using a compressor that handles 15 cu.ft. of free air per minute? P. T. M.

A tank capacity of 8,000 gal. $= \frac{8{,}000}{7.48}$ or 1,069.5 cu.ft. Assuming constant temperature, the volume of air is inversely as the pressure above absolute zero. Hence, when the tank contains air compressed to 50 lb. gage, or $50 + 14.7 = 64.7$ lb. per sq.in. absolute, its volume, when expanded at constant temperature down to atmospheric pressure, or 14.7 lb. absolute, would be $1{,}069.5 \times 64.7 \div 14.7 = 4{,}707.2$ cu.ft. of air at atmospheric pressure, or on the other hand, when 4,707.2 cu.ft. of free air is compressed at constant temperature from atmospheric pressure to 50 lb. gage, its volume would be 1,069.5 cu.ft., or 8,000 gallons.

If, to begin with, the tank holds 1,069.5 cu.ft. of air at atmospheric pressure, then the compressor would be called upon to handle $4{,}707.2 - 1{,}069.5 = 3{,}637.7$ cu.ft. of free air, and if the compressor takes in 15 cu.ft. of free air per min., the number of minutes required to pump 3,637.7 cu.ft. of free air into the tank and thereby raise the pressure to 50 lb. gage, or 64.7 per sq.in. absolute, would be $3{,}637.7 \div 15 = 242.5$ min., or 4 hours, $2\frac{1}{2}$ minutes.

A simple arithmetical statement of the problem would be

$$\left[\left(1069.5 \times \frac{50 + 14.7}{14.7}\right) - 1069.5\right] \div 15 = 242.5 \text{ min.,}$$

or 4 *hr.* $2\frac{1}{2}$ *min.*

The temperature of the air will be increased by the process of compression and, without leakages, a fewer number of cubic feet of free air would be required, because of expansion due to heat, but it will be on the safe side to assume that the increase of volume due to rise of temperature will be offset by leakage and cooling.

Refrigerating Duty

In our plant we are circulating 100 lb. of brine per minute., specific gravity 1.187, temperature at entrance 10 deg. F., exhaust 20 deg. F. We also freeze 144 cans of ice, each 100 lb. in weight, in 24 hours, with water 60 deg. F., ice-tank temperature 15 deg. F. What refrigeration duty do we secure from the plant? M. J. M.

Taking up the brine to cold storage first, the refrigeration secured is the product of weight of brine circulated per minute times the difference between entrance and outlet temperatures, times the specific heat of the brine and the result divided by 200, this latter being the B.t.u. per minute equivalent to a ton of refrigeration daily, or $R = W\left(\frac{T_1 - T_2}{200}\right)C$.

In the problem $W = 100$, $T_1 = 20$, $T_2 = 10$, and C for brine of 1.187 gravity is 0.795; hence $R = \frac{100\ (20 - 10)\ 0.795}{200} = 3.975$ tons.

For the ice tank 144 one hundred pound cans, frozen in 24 hours = 10 lb. per min. To lower one pound of water from 60 deg. to 32 deg. (freezing temp.) = $(60 - 32)\ 1 = 28$ B.t.u., and to lower from 32 deg. to 20 deg. (assuming that the ice is cooled to 20 deg. F. since the brine tank temperature is 15 deg. F.) will require $1\ (32 - 20) = 12$ B.t.u. The total heat removed in freezing is then $28 + 144 + 12 = 184$ B.t.u. per pound of ice frozen. For 10 pounds per minute the duty is $\frac{184 \times 10}{200} = 9.2$ tons. The total refrigeration duty is $9.2 + 3.975 = 13.175$ tons.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Two Important Water Power Applications Filed

Applications received by the Federal Power Commission during the week ended Nov. 19 are as follows: William J. Barker, Southern Bldg., Washington, D. C., applied for a preliminary permit covering a power development on the Colorado River near Kremmling, Col. The reservoir is to have a capacity of 1,080,000 acre-feet. A tunnel to the power house is expected to permit of the development of 52,000 hp. The installed capacity is to be 65,000 horsepower.

The Northwestern Electric Co., of Portland, Ore., applied for a preliminary permit covering three separate developments on the North Fork of Lewis River in Clarke and Cowlitz Counties, Washington. The power capacity is estimated at 65,800 hp. and the installed capacity at 125,000 hp. This application conflicts with that of the Lewis River Hydro-Electric Power Co., of Vancouver, Washington.

Work at Duncan's Riffle Shows Southern Activity

The Alabama Power Co. is now employing 900 men at good wages, on the construction of the big dam at Duncan's Riffle, on the Coosa river, 50 miles southeast of Birmingham, Alabama. The coffer-dam has been constructed halfway across the stream, and the foundation for the other half is now being blasted out. Within the next few days the pouring of cement will be started, and the big dam will then begin to assume definite proportions.

The dam will be 1,125 ft. long, 75 ft. high and 74 ft. wide at the base, and will provide 115,000 hp. The project will be one of the largest dams and hydro-electric plants in the South. Since the commencement of work on the dam a few months ago, quite a village has sprung up at Duncan's Riffle, and a 14-mile railroad has been built from the site of the dam to Verbena, Ala., joining the main line of the Louisville & Nashville Railroad.

The construction of this plant by the Alabama Power Co. was made necessary by increasing demands for both power and light. The demand for electric power especially, is constantly on the increase in Alabama, owing to the establishment of a number of new factories and the enlargement of old ones. As an illustration, in Birmingham alone, over 300 new factories, all using electric power, have located since the year 1917. With the almost unlimited supply of coal and iron in the country surrounding Birmingham, this city is becoming a great manufacturing center.

Government Work as Cure for Industrial Depression

An editorial in the Nov. 1 issue of *Power*, entitled "'Prosperity as the Cause of Unemployment," called attention to the proposition, which was advanced at the Washington conference on unemployment, that the time to prevent periods of industrial depression and unemployment is at the height of the boom that always precedes hard times. It may be of interest, then, to note that this idea has been incorporated in a bill that Senator Kenyon recently introduced in the Senate.

The preamble of the bill states: "Whereas, a sound economic policy requires that a larger percentage of the public works and projects of the United States be undertaken and prosecuted during a period of major industrial depression and unemployment, when labor and capital are not fully employed in private industry, that a smaller percentage of such works and projects should be undertaken and prosecuted during a period when private industry is active and competing for the same men and material with resulting business strain and over-extension, and that the prosecution of such works and projects should be utilized as a stabilizing force during a period of over-expansion as well as during a period of depression."

As a means of carrying out this purpose the bill provides that the Secretary of Commerce is to keep the Government informed of coming changes in business conditions and authorizes the heads of the executive departments of the Government, upon advice of the President, to postpone public work in prosperous times and to do as much as possible of it in periods of depression.

Edward Eyre Hunt, secretary, of the President's Conference on Unemployment, said of the proposed bill: "I believe this is one of the most important results of the Unemployment Conference."

Profit-Sharing Fallacy

The following table illustrates how slowly labor's share of the selling price increases with increased profits, as explained in the editorial on pages 897 and 898.

FIRST CASE

	Labor's Share	Capital's Share	Capital / Labor
Profit 10,	$\frac{40}{110} = 0.364$	$\frac{10}{110} = 0.091$	0.25
Profit 20,	$\frac{40}{120} = 0.333$	$\frac{20}{120} = 0.167$	0.50
Profit 30,	$\frac{45}{130} = 0.346$	$\frac{25}{130} = 0.193$	0.561
Profit 40,	$\frac{50}{140} = 0.351$	$\frac{30}{140} = 0.215$	0.61
Profit 50,	$\frac{55}{150} = 0.367$	$\frac{35}{150} = 0.233$	0.63
Profit 60,	$\frac{60}{160} = 0.375$	$\frac{40}{160} = 0.250$	0.67
Profit 70,	$\frac{65}{170} = 0.382$	$\frac{45}{170} = 0.265$	0.69
Profit 80,	$\frac{70}{180} = 0.389$	$\frac{50}{180} = 0.278$	0.71
Profit 90,	$\frac{75}{190} = 0.395$	$\frac{55}{190} = 0.289$	0.73
Profit 100,	$\frac{80}{200} = 0.400$	$\frac{60}{200} = 0.300$	0.75

SECOND CASE

	Labor's Share	Capital's Share	Capital / Labor
Profit 10,	$\frac{90}{110} = 0.82$	$\frac{20}{110} = 0.18$	0.22
Profit 20,	$\frac{90}{120} = 0.75$	$\frac{30}{120} = 0.25$	0.33
Profir 30,	$\frac{95}{130} = 0.73$	$\frac{35}{130} = 0.27$	0.37
Profit 40,	$\frac{100}{140} = 0.71$	$\frac{40}{140} = 0.29$	0.41
Profit 50,	$\frac{105}{150} = 0.70$	$\frac{45}{150} = 0.30$	0.43
Profit 60,	$\frac{110}{160} = 0.69$	$\frac{50}{160} = 0.31$	0.45
Profit 70,	$\frac{115}{170} = 0.68$	$\frac{55}{170} = 0.32$	0.47
Profit 80,	$\frac{120}{180} = 0.67$	$\frac{60}{180} = 0.33$	0.49
Profit 90,	$\frac{125}{190} = 0.66$	$\frac{65}{190} = 0.34$	0.51
Profit 100,	$\frac{130}{200} = 0.65$	$\frac{70}{200} = 0.35$	0.54

A successful test has recently been made on an internal-combustion marine engine of the Tosi type in the Beardmore shops in England, according to the London *Engineer*. The engine is of the four-stroke cycle, single-acting, six-cylinder type, and on a 100-hour test delivered an average of 1,267 b.hp. on 0.42 lb. of fuel per b.hp.-hr. It is to be installed in the "Pizarro," a cargo vessel.

News in the Field of Power

Superpower Report Out

The official report of the Superpower Survey, entitled "A Superpower System for the Region Between Boston and Washington," has been printed and will shortly be made available to the public by the Superintendent of Documents, Washington, D. C. It is known as "Professional Paper 123."

The great amount of work done by the Survey is reflected in the formidable size of the report, which is about the size of *Power* and contains 260 pages, including numerous diagrams, tables and charts, and several large colored maps of the Superpower district. The data contained between its covers are likely to prove highly valuable to all concerned with such work.

Chicago Engineers "Reminisce"

The Chicago Section of the American Society of Mechanical Engineers held a joint meeting Nov. 21 with the Western Society of Engineers, in the lecture hall of the latter organization, in the Monadnock Building, at which the topic was "Engineering Experiences." The speakers were four prominent engineers of the city: R. W. Hunt, of R. W. Hunt & Co.; P. W. Gates, of the Hanna Engineering Co.; H. C. Gardner, of Gardner & Lindberg, consulting engineers; and W. L. Abbott, of the Commonwealth Edison Co.

Mr. Gates painted a vivid picture of engineering conditions during the development of the West, tracing, as he did so, the rise of the Gates Iron Works, which was established by his father and finally absorbed by the Allis-Chalmers Manufacturing Co. in 1901. During the Civil War this iron works cast some cannon balls that were sent in the nick of time to Cairo to stop the Confederate invasion.

R. W. Hunt reviewed his early life in the steel mills. He had worked his way through the rolling mills at Pottsville, Pa., and then studied chemistry and metallurgy at Philadelphia before introducing the first laboratory for steel analysis at the Cambria works. He recited the operating troubles at the time of the introduction of the bessemer process and during blast-furnace developments, paying a tribute incidentally to William Jones, who by his engineering and inventive ability did so much for the steel business. He was the man who had started Charles Schwab on his way through the mills.

H. C. Gardner, who for years had been with Swift & Co., before entering consulting circles, discussed the early refrigeration system in the stock yards. Before 1887, ice had been the accepted means of cooling, but during that year the ice crop was so low that Mr. Gardner installed a brine system in a new cooler at Kansas City. It was at this time that his troubles began, for the cast-iron pipe rusted too readily and pin holes developed in the galvanized pipe.

In a humorous way W. L. Abbott told of his experiences in the lighting industry. Although he had been required to leave several electric light companies because they went into bankruptcy, he still stuck with the industry. Mr. Abbott dwelt upon his work at the Harrison Street Station and traced developments that had been made since this plant was one of the great stations of the country. Since that time great improvements had been made in methods of operation and in the economy obtained. It was his feeling, however, that the practical limits of the steam cycle had been nearly reached and no large increase in economy could be expected for the future.

Business Is Sober

MANY are asking, "When will business come to life?" Business is not dead; it is suffering from its past intoxication. Now it is sober—very sober. Goods are being bought—but the price must be right. Work is being done—but it must be done well. Men are being hired—if they are able.

What does this mean to the power-plant man? It means that, as never before, he must stop the leaks. He must save fuel. He must shave costs. If the power department doesn't fall in line with the general effort to reduce waste, the man in charge will look for another job.

That is the idea back of POWER'S service today—to give every possible help to its readers in meeting the scrutiny of critical, sober business.

Federation Activities To Cover Eight Districts

A change has been made in the policy of regional activity of the Federated American Engineering Societies, as the result of a recent decision of the Executive Board of American Engineering Council. The regional work is now divided among eight districts instead of six, and they are arranged on the basis of unity of local interest instead of equality in numerical membership. It is planned to put the new plan into effect Jan. 1, 1922.

The districts are as follows: No. 1, known as the New England and New York district—Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut and New York; No. 2, Great Lakes — Michigan, Wisconsin and Minnesota; No. 3, Ohio Valley—Ohio, Indiana, Illinois and Kentucky; No. 4, Middle Atlantic States—Pennsylvania, New Jersey, Delaware, Maryland, Virginia, West Virginia and the District of Columbia; No. 5, South Atlantic and Gulf States—North and South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Tennessee; No. 6, North Mississippi and Missouri Valley—Iowa, Missouri, Kansas, Nebraska, North and South Dakota, Wyoming, Utah and Colorado; No. 7, South Mississippi Valley and Gulf—Oklahoma, Arkansas, Texas, New Mexico and Arizona; No. 8, Pacific Coast—Washington, Oregon, Montana, Idaho, California and Nevada.

High Dam Project at Twin Cities in Dispute

The "high dam" project between St. Paul and Minneapolis will probably be taken up at the next meeting of the Federal Power Commission. It is generally felt that the Nothern States Power Co. could handle the development to the best advantage, but Senator Nelson of Minnesota insists that the project should be turned over to the municipal corporation comprising the Cities of St. Paul and Minneapolis and the University of Minnesota.

Senator Nelson argues that the Northern States Power Co. is a monopoly and that its monopoly would be strengthened by control of this project. On the other hand the municipal corporation has been in existence since 1911 and has done nothing toward developing the project.

The City of St. Paul is making an independent effort to get control of the water power, although this effort is regarded by some to be in fact a move of Henry Ford, as it is understood that he would have first call on the power if the city were to control the project.

A Canadian Slant on the Worth of the Business Press

Col. Henry Cockshutt, Lieutenant Governor of Canada and a successful business man, paid an understanding tribute to the business papers of Canada in a recent address, saying:

I am especially glad to be with you today because I believe that the influence of the business press will be one of the most important factors in re-establishing business conditions in Canada on a safe and sane basis. I make a distinction between the business newspapers and the daily press because I believe that your papers—the business newspapers of Canada—exert a greater influence than the daily press because of the greater confidence your readers have in them.

In these days when there is disorganization, dissension, disruption in all walks—business, politics and religion—there is a great place for the business paper to bring out more complete information, to assist in making us all realize we must work for a common cause, the upbuilding of our country.

Five Hydro Plants Planned in Louisiana

A preliminary permit has been authorized by the Power Commission for a comprehensive power development in southwestern Louisiana in connection with a large system of reservoirs and irrigation canals.

Five power plants are proposed, working under comparatively low heads from about 13 to 49 ft. The Louisiana Gravity Canal Co., which is planning the work, estimates the capacity of the five plants at 55,000 hp. The different stations will be interconnected, and the power will be used for construction purposes and for canal operation, and will also be supplied for domestic and manufacturing needs.

Money Lacking for Weekly Coal Reports

The United States Geological Survey has for some time been issuing its weekly coal reports under the difficulty of inadequate funds, and the situation reached such a point recently that it gave notice of its inability to continue the reports.

A similar situation arose once before, and the National Coal Association supplied enough money to turn out the reports until the new appropriation was made, but it is felt that the reports benefit many others besides the association and that the Government should bear the expense. Hence, the association has not repeated its offer of funds, but its board of directors has passed unanimously a resolution requesting transfer of the work of the coal reports from the Geological Survey to the Department of Commerce.

It is known that the Department of Commerce has the necessary money and facilities and could turn out the reports if authorized to do so. The President is studying the matter, and there is some doubt as to what decision he will make.

Bureau of Standards Tests Ball and Roller Bearings

The United States Bureau of Standards has made a number of experiments to find the maximum safe load and the static friction under load of ball and flexible roller bearings, and has put the results of these tests into Technologic Paper No. 201, "Friction and Carrying Capacity of Ball and Roller Bearings," which is sold by the Superintendent of Documents for ten cents. The tests were made on balls of 1 in., 1¼ in. and 1½ in. diameter in grooved races and on rollers 1¼ in. in diameter and 5¼ in. long in flat and cylindrical races, extreme pressure being applied to them by the bureau's special machinery. The results of these experiments are summarized as follows:

1. The results agree roughly with Hertz's theory. The differences are ascribable to inhomogeneity of the material.

2. The ratio of friction to load is practically constant and equal to 0.00055 for all three sizes of balls up to a "critical" load, which varies with the diameter of ball: 1,300 lb. for 1 in., 1,700 lb. for 1¼ in., and 2,200 lb. for 1½ in. balls.

3. A similar "critical" load, 25,000 lb., was found for the roller bearings with a ratio of friction to load equal to 0.00075.

4. This "critical" load at which the friction began to increase more rapidly was in all cases lower than the safe load as determined by permanent deformation and as calculated from Stribeck's law.

Does Increased Value Justify Increased Rates?

Another chapter in the long dispute between the courts and the Potomac Electric Power Co. came to a close recently, when the Court of Appeals of the District of Columbia reversed the opinion of the late Justice Gould and held that the increase in value of the company's property since the rate was originally set ought to be considered in setting the new rate. The case has been in dispute since 1917 and is still a long way from being settled. The present decision was not unanimous, but was approved by Justices Robb and Van Orsdel, while Chief Justice Smyth dissented. The Public Utilities Commission, which made the original valuation, is to appeal from this decision to the United States Supreme Court.

In explaining his point of view, Justice Robb said in the course of his opinion: "It has been ruled many times that there must be a fair return to a public utility upon a reasonable value of the property at the time it is being used for the public." He explained that the commission declined to do this because of the uncertainty of changing prices, but pointed out that it would have been entirely free to revise the rate in case of a later change in prices.

Chief Justice Smyth, taking the opposite viewpoint, held that any increase in the value of the company's property should not affect the rate charged because such increase was due to the war and the resulting demoralized market condition and did not result from any outlay by the company.

The case now goes to the Supreme Court. While the opposing counsel continue to argue enthusiastically, the consumers continue to pay 10c. per kw.-hr. and the company continues to accumulate a fund that may turn out to be a goodly nest egg for its stockholders or a welcome rebate to its consumers, according to the eventual settlement.

An investigation into coal and other railroad rates will be begun Dec. 14 at Washington by the Interstate Commerce Commission.

Obituary

Leon H. Scherck, of the Central Hudson Gas and Electric Co., of Poughkeepsie, N. Y., died at his Poughkeepsie home, Nov. 16. He was born in New Orleans in 1875, was educated at Tulane University and worked with a number of public-utility companies.

Alfred Roland Van Horne, inventor of an automatic device for the control of isolated power plants, died recently at the early age of 35. He was educated at Pennsylvania State College and Drexel Institute, and spent most of his life in experimenting and manufacturing.

Warren H. Fiske, a fellow of the A. I. E. E., died recently of acute appendicitis. He was born in Somerville, Mass., in 1869 and was graduated from Tufts College in 1891. His experience was largely in steam and hydraulic power plants in many different places, including New York, Toronto, Mexico City and Barcelona, Spain. Before the war he worked at Muscle Shoals.

Charles R. Cross, professor of physics emeritus of Massachusetts Institute of Technology, and a charter member of the A. I. E. E., died Nov. 16 in Brookline, Mass. Professor Cross was born in Troy, N. Y., in 1848, and was graduated from the Massachusetts Institute of Technology in 1870. He remained all his life with the Institute, and had a notable part in the development of its electrical engineering courses. Besides being a member of the A. I. E. E. since 1884, he was a fellow of the American Academy of Arts and Sciences, a member of the American Physical Society, British Association for the Advancement of Science, and past-chairman of the American Association for the Advancement of Science and of the Rumford Fund Committee.

Personals

Charles H. Yost has left the General Electric Co., and has located with the Niagara, Lockport and Ontario Power Co., of Buffalo, N. Y.

C. F. Schoonmaker, formerly assistant engineer with the Quaker Oats Co., Chicago, is now with The Iowa Railway and Light Co., Cedar Rapids, Iowa.

William Moody has left the Cramp and Sons plant in Philadelphia for Charles C. Moore & Co., San Francisco, Cal., which is the Pacific Coast branch of the Babcock & Wilcox Co.

J. P. Greenwood, consulting engineer, of Dallas, Texas, has been appointed mechanical engineer to the State Board of Control, and is to have charge of operation of the State institutions' power plants.

William Howard Grove, previously with the Republic Railway and Light Co., of New York, has joined the electrical engineering department of the Cleveland Electric Illuminating Co., of Cleveland, Ohio.

T. W. Carraway has left his work with the government as chief engineer, United States Government Repair Unit No. 304, to form the Carraway Engineering Co., of San Antonio, Tex., specializing in mechanical refrigeration.

Society Affairs

Coming Conventions

American Society of Refrigerating Engineers — Annual meeting at New York City, Dec. 5-7. Secy., William H. Ross, 154 Nassau Street, New York City.

American Society of Mechanical Engineers—Annual meeting at New York City, Dec. 5-9. Topic, "Elimination of Waste." Sec., Calvin W. Rice, 29 West 39th St., New York City.

American Institute of Electrical Engineers—Midwinter Convention at New York City, Feb. 15-17. Secy., F. L. Hutchinson, 29 West 39th St., N. Y. City.

Lehigh Valley Section, A. I. E. E., will meet Dec. 10 at Nazareth, Pa., for a discussion of "Electrification of Cement Mills."

Worcester Section, A. I. E. E., is to meet Dec. 15 for a talk on "Electric Meters," by A. R. Rutter, of the Westinghouse Co.

Toledo Section, A. S. M. E., is to meet Dec. 15 for addresses on "Gas Manufacture, Distribution, etc.," by A. Johnson, and on "Industrial Fuel," by Henry O. Loebell, of the Henry L. Doherty Co. Motion pictures will be shown.

Bridgeport Branch, A. S. M. E., is to meet Dec. 15 for an address on "World Wide Industrial Conditions," by Dr. Magnus W. Alexander, chairman of the National Industrial Board.

The American Association for the Advancement of Science and associated societies are to meet in Toronto, Canada, Dec. 27-31. The permanent address is the Smithsonian Institution, Washington, D. C.

Meridan Branch, A. S. M. E., (Conn. Section), will meet at 8 p. m., Dec. 15, in the Home Club, on Colony Street. "The Transportation and Storage of Coal" will be discussed and Harry R. Westcott, of Westcott & Mapes, will tell of the "Development of the Grand Avenue Station of the United Illuminating Company of New Haven."

Metropolitan Section, A. S. M. E., will meet Dec. 16 in the Engineering Societies Building, New York City, to discuss "Pulverized Fuel." The evening meeting will follow a trip in the afternoon through the plant of the Babcock & Wilcox Boiler Co., at Bayonne, N. J. There will be several speakers from many different states, and they will all speak on "Pulverized Fuel from the Operating Standpoint."

Connecticut Section, A. I. E. E., will meet at 8 p. m. Dec. 15 in the auditorium of the Hartford Electric Light Co., at Hartford, for an illustrated lecture on the new 60,000-hp. Caribou plant of the Great Western Power Co., in California, by Albert A. Northrop, hydraulic engineer with Stone & Webster. A 3,500-ft. motion-picture film and some colored slides will help to tell the story.

Business Items

The Exeter Machine Works, Inc., of West Pittston, Pa., has appointed the H. M. Stark Machinery Co., of Detroit, Mich., exclusive sales agent for the Exeter Rotary Pump line in the Detroit district.

The Quigley Furnace Specialties Co., 26 Cortlandt St., New York City, has appointed as sales engineer Robert L. Warburton, formerly with the Celite Products Co. and experienced in problems of furnace design and heat insulation.

The Westinghouse Electric International Co., East Pittsburgh, Pa., has announced that H. C. Soule, manager of the apparatus department, sailed from New York on Nov. 19 for Buenos Aires, Argentina, where he will take up duties for the Argentine company.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Nov. 21, 1921	Nov. 28, 1921
Pool 1,	New York	$3.05	$2.75@3.25
Pocahontas	Columbus	2.35	2.25@2.50
Clearfield	Boston	1.80	1.60@2.00
Somerset	Boston	1.75	1.65@2.00
Pittsburgh	Pittsburgh	2.15	2.10@2.20
Kanawha	Columbus	3.20	3.00@3.25
Hocking	Columbus	2.00	1.90@2.10
Pittsburgh No. 8	Cleveland	2.00	2.00@2.10
Franklin, Ill.	Chicago	2.85	2.50@3.00
Central, Ill.	Chicago	2.50	2.00@2.75
Ind. 4th Vein	Chicago	2.75	2.60@2.90
Standard	St. Louis	1.95	1.85@2.00
West Ky.	Louisville	1.90	1.75@2.00
Big Seam	Birmingham	2.00	1.50@2.50
S. E. Ky.	Louisville	2.20	2.00@2.25

New York — On Nov. 30 Port Arthur light oil 22@25 deg Baumé, 5c. per gal.; 30@35 deg., 6c. per gal., f.o.b. Bayonne, N. J.

Chicago—Nov. 26, for 24@28 deg. Baumé, 95c.@$1 per bbl.; 32@36 deg., 3@3¼c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh — On Nov. 28 f.o.b. refinery, Pennsylvania, 36@40 deg., 6@6¼c. Oklahoma, 24@30 deg., 80@90c. per bbl.; gas oil, 32@34 deg., 3@3¼c. per gal., 36@38 deg., 3¼c., 38@40 deg., 3½c. per gal.

St. Louis — Nov. 26, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 90c. per bbl.; 26@28 deg., $1; 28@30 deg., $1.10; 32@34 deg., 2¾c. per gal.

Philadelphia — On Nov. 28, 26@28 deg. Baumé, Oklahoma, $1.05@$1.20 per bbl.; 30@34 deg., Oklahoma (group 3), 3@3¼c. per gal.; 16@20 deg. Seaboard, $1.15 per bbl.

Cincinnati — Nov. 23, for 24@30 deg. Baumé, 5¾c.; Diesel, 30@32 deg. 6¼c. per gal.; 34@36 deg., 6¾c. per gal.; 38@40 deg., 6¾c. per gal.

Cleveland — Oct. 31, for 24@30 deg. Baumé, 4¾c. per gal.

New Construction

PROPOSED WORK

Me., Portland—The Bd. Educ. is having plans prepared for a 3 story high school in the Deering district. About $500,000. Poor & Thomas, 537 Congress St., Archts.

Mass., Rutland—The Treasury Dept., J. A. Wetmore, Supervising Archt., received bids for mechanical equipment in the United States Public Health Service Hospital from the G. E. Engr. Co., 449 West 42nd St., New York City, $146,300; Ranson and Anderson, 136 Liberty St., New York City, $153,880 and C. J. Gleason, 1526 Walton Way, Augusta, Ga., $156,300. Noted Nov. 1.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York City, will soon receive bids for a P. S. No. 187, 65th St. and 12th Ave. About $1,000,000. C. B. J. Snyder, 28th St. Municipal Bldg., New York City, Archts. and Engrs. Noted May 10.

N. Y., New York—S. Gittenberg, 713 East 136th St., is having plans prepared for a 6 story apartment on Grand Concourse and 173rd St. About $325,000. C. Kreymborg, 2534 Marion Ave., Archt. and Engr.

N. Y., New York — N. J. Hayes, Comr. Water Supply, Room 2351 Municipal Bldg., will receive bids until Dec. 9 for furnishing, installing and connecting a boiler at the 98th St. pumping station.

N. Y., New York—The Interzone Corp., c/o C. Gilbert, Archt., 244 Madison Ave., is having plans prepared for a 14 story, office building. About $550,000.

N. Y., New York—W. H. Meyer, Archt., 1861 Carter Ave., will soon receive bids for a 4 story cold storage plant on Webster Ave. About $100,000. Owner's name withheld.

N. Y., Saltaire (Summer P. O.)—The city is having plans prepared for a distribution system, pumping station, tower and tank. G. L. Watson, 16 East 41st St., New York City, Consult. Engr.

Pa., Aspenwall (Pittsburgh P. O.)—E. P. Melbon, Archt., 52 Vanderbilt Ave., New York City, will receive bids until Dec. 12 for a school and two 2 story dormitory bldgs. for the Shadyside Academy, Pittsburgh. Bids will be received later on auditorium, gymnasium, dining hall and power plant.

Pa., Lansdale—The Borough, A. Durk, Supt., plans to build an addition to electric power plant, also install new power equipment. Engineer not selected.

Pa., Philadelphia—The Comn. of Fairmount Park, c/o T. S. Martin, City Hall, will soon receive bids for a 2 story, 213 x 313 ft. library on the Parkway. About $3,000,000. H. Trumbaner, Land Title Bldg., Archt.

Pa., Philadelphia—Escourt Hotel Co., 910 Ridge Ave., plans to build a 4 story, 45 x 60 ft. cold storage plant and stores at 913-15 Ridge Ave. About $100,000. Architect not selected.

Pa., Philadelphia—The Logan Market House Co., c/o R. R. Meely, Archt., 2136 Pine St., is having preliminary plans prepared for a 3 story, 50 x 100 and a 1 story, 100 x 200 ft. stores and market and a refrigeration plant. About $500,000. A steam heating system will be installed, also refrigerating machinery.

Pa., Pittsburgh—The U. S. Lock Nut Corp., 400 North Michigan St., Chicago, Ill., plans to build a manufacturing plant here. About $500,000. Architect not selected.

Pa., Pottstown—Burdan Bros., 2nd St., will soon award the contract for a 4 story ice cream factory. About $125,000. Lackman & Murphy, Drexel Bldg., Phila., Archts. Ice and ice cream machinery will be installed.

Pa., Reading—The City Council will receive bids until Dec. 14 for the following contracts:

No.
12 Foundation for boiler house.
13 20-ton auto truck scale.
14 Cast Iron Ash Hoppers.
15 One 800 G.P.H. water softener.
16 Venturi feed water meters and register.
17 Boiler Settings.
18 Combustion control.
19 Two 25 kw. turbo generators.

D. E. Dampman, Supt. Dept. Parks and Public Property.

Pa., Washington—The Tyler Pipe & Tube Co., is receiving bids for a 1 story, 20 x 50 ft. and 50 x 50 ft. tubes and pipe producer house and boiler plant. About $50,000. Simplex Eng. Co., Washington Trust Bldg., Engr.

Md., Cumberland—The George Washington Hotel Co., C. S. Catherman, 12 South Centre St., is having plans prepared for a 7 story, 100 x 175 ft. hotel. About $900,000. Esenwein & Johnson, Ellicott Sq. Bldg., Buffalo, N. Y., Archts.

W. Va., Albright—The West Virginia & Maryland Power Co., Tunnelton, plans to construct a central generating plant on Chest River near here, for the supply of light and power along the Morgantown & Kingwood R.R.

W. Va., Grafton—The city is having plans prepared for the construction of a 3,000,000 gal. filtration plant, pumping station and 2,000,000 gal. reservoir, also 3 mi. water mains. About $200,000.

W. Va., Wheeling—Tri-State Security Co., 1129 Market St., is having preliminary plans prepared for a 14 story, 68 x 125 ft. hotel on 14th and Market Sts. About $1,000,000. H. E. Shimmin, 2031 Euclid Ave., Cleveland, O., Archt.

Fla., Cocoa—Weidensee, Alexander & R. W. Powers, Washington Ave., purchased a site and plans to build a 4 or 5 story, 100 x 110 ft. hotel. About $500,000.

Miss., Centreville—The city, H. S. Archer, Clk., is in the market for complete equipment for electric light plant.

La., New Orleans—The House and Medical Committee have been authorized to investigate and report on additions, improvements and equipment including the installation of electric light plant at the Charity Hospital of New Orleans. Cost of plant not to exceed $25,000.

Tenn., Memphis—The Southwestern University, Clarksville, is having plans prepared for college building consisting of dormitory, academy halls and heating plant. About $1,000,000. H. C. Hibbs, 412 4th & 1st Natl. Bank Bldg., Nashville, Archt.

Ky., Louisville—The Grand Lodge of Kentucky, Masonic Temple, Flexner Bldg., is having plans prepared for widows' and orphans' home 15 or 20 separate units of 2 story each. About $1,500,000. Joseph & Joseph, Francis Bldg., Archts.

O., Ashtabula—Silurium Mfg. Co., c/o E. W. Steinbrenner, Sloan Bldg., Cleveland, is having plans prepared for a 1 and 2 story factory including a steam heating plant. About $250,000. A. W. Harris, Schofield Bldg., Cleveland, Archt. Noted May 23.

O., Canton—The Canton Ice & Fuel Co., 601 4th Ave., N. E., has had plans prepared for a 1 story, 30 x 100 ft. addition to ice plant. About $40,000. A. C. Bishop & Co., 427 Guardian Bldg., Cleveland, Archts. and Engrs.

O., Cleveland—The city will receive bids until Dec. 9 for furnishing 4 water tube boilers and mechanical stokers for Division of Water. About $400,000. A. V. Ruggles, City Hall, Engr.

O., Cleveland—The city plans to install electric equipment in the city light plant to include switchboard and station equipment, transformers, regulators, etc. Total cost, $130,000. C. G. Beckwith, City Hall, Engr.

O., Dayton — The city, F. O. Bischelberger, Mgr., plans to build a 10 story, 80 x 250 ft. municipal bldg. on Main St. About $950,000. Architect not selected.

O., Dayton—L. G. Cooper, 301 East 1st St., plans to build a 6 story, 60 x 110 ft. medical office building on 1st and Main Sts. About $500,000. Architect not selected.

O., Youngstown—The Terminal Bldg. Co. plans to build a 6 story addition to office building on Phelps St. About $500,000.

Ind., Marion—The city will soon receive bids for alterations to pumping station and installation of 5,000,000 gal. steam pump. About $75,000. Alvord & Burdick, 8 South Dearborn St., Chicago, Ill., Engrs.

Ill., Chicago—H. C. Christenson, Archt., 7258 Union Ave., is receiving bids for a 125 x 250 ft. ice plant including equipment on Talman Ave. and 12th St. Owner's name withheld.

Ill., Lyons—The city, c/o W. Smith, Clk., is having plans prepared for water mains, reservoir and pumping station. About $40,000. E. Hancock, 2047 Ogden St., Chicago, Engr.

Ill., Shelbyville—The city is having plans prepared for an electric light and power plant. About $75,000. Fuller & Beard, Railway Exchange Bldg., St. Louis, Mo., Engrs.

Wis., Fond-du-Lac — The Combination Door Co., 180 Ruggles St., is in the market for electric motors.

Wis., Janesville—The School Bd., L. Zieman, Clk., will receive bids until Dec. 12 for steam heating, plumbing, etc., for high school now under construction. Total cost about $800,000. Van Ryn & De Gelleke, 114 Grand Ave., Milwaukee.

Wis., Milwaukee—The Bd. of Mgrs. of Natl. Homes, D. V. S., Dayton, O., C. Wadsworth, Genl. Treas., is having plans prepared for a 1 story, 90 x 100 ft. service bldg., a 42 x 120 ft. administration bldg. and four 58 x 290 ft. ward bldgs. at the Soldiers Home, here. About $1,400,000. Scott & Mayer, 445 Milwaukee St., Archt.

Wis., Racine—The E. L. M. Tire Co., Deane Blvd., is having plans prepared for a 2 story, 148 x 160 ft. addition to factory. Private plans. Special machinery and motors will be installed.

Wis., Williams Bay—The village is having preliminary plans prepared for a new water supply system including elevated steel water tank, pumping station and equipment, also watermains. W. S. Shields, 8 South Dearborn St., Chicago, Ill., Engr.

Ia., Davenport—The Chicago, Milwaukee & St. Paul R.R., Ry. Exchange Bldg., Chicago, Ill., plans to build a 4 story railroad station including a steam heating system. About $800,000. C. R. Rawson, 80 East Jackson Blvd., Chicago, Ill., Archt.

Minn., St. Paul—R. C. Cobb Co., 2 East 3rd St., is having plans prepared for a 6 or 7 story, 70 x 120 x 140 ft. office and warehouse including a steam heating system. About $350,000. A. H. Stem, 601 Endicott Bldg., Archt.

Neb., Lincoln—(Change of date)—The city will receive bids until Dec. 13 for the installation of a 1,000 hp. economizer, vertical cast iron tube type, engine driven, steel plate type, induced fan, chain grate stokers and superheaters for two 500 hp. boilers, one open feed water heater for 4,500 lbs. per hr., one hot process water softener, 2,000 gal. per hr., one centrifugal motor driven, boiler feed pump, 150 gal. per min. and 2 soot blowers. About $42,000. G. W. Bates, Engr. Noted Nov. 29.

S. D., Frederick—The city, c/o J. F. Mellen, Clk., is having plans prepared for extensions to water mains, reservoir and pumping station. About $40,000. J. A. Rowatt, Tallman Bldg., Willmar, Minn., Engr.

Tex., Robstown—The Water Improvement Dist. No. 3 plans to construct a waterworks system, and irrigation system including canals, ditches, etc., a pumping plant, and relift station. Total cost about $300,000. Walton & Arneson, Gunter Bldg., San Antonio, Engrs.

Col., Denver—The L. R. Steel Service Corp., 406 Guardian Trust Bldg., will receive bids about Jan. 1 for a 4 story, 100 x 125 ft. retail store building, including a vapor heating system on 16th and Welton Sts. Cost between $350,000 and $400,000. M. H. Hoyt, Colo. Natl. Bank Bldg., Archt.

Idaho, Twin Falls—The Milner Low Lift Irrigation Dist. plans to purchase works from the Murtaugh Canal Co. and complete the system, 500 hp. motor, direct connected to 24 in. centrifugal pumps will be installed in main plant. New plant No. 2 to be constructed to include two 40 hp. induction motors with 10 in. pumps and one 10 hp. 6 in. pumps. Cost of new construction about $50,000.

Wash., Keyport — The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for a 210 ft. radio tower at the Naval Radio Station, here, from C. F. Marten, 4120 Dayton Ave., Seattle, $5,713.13; J. A. McEachean, 552 Coleman Bldg., Seattle, $7,431; Ward & Ward, Inc., 626 Perkins Bldg., Tacoma, $7,800. Spec. 4538.

Ore., Burns—The Harney Valley Irrigation Dist., voted bonds for system to irrigate 87,000 acres, near here, to include earth fill dam, 110 ft. high to form reservoir, 150,000 acre ft. capacity on Silvies River, 1,000,000 cu.yd. earth fill. Reservoir to cost $1,400,000. Total cost, $2,000,000. Baar & Cunningham, 4135 Paulding Bldg., Portland, Engrs.

Ore., McMinville—The city has made application for permit to appropriate 35 second ft. water through tunnel and pipe line 5 mi. long head of 1,460 ft. for development of 58,070 hp. About $350,000.

Cal., Eureka—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for a 300 ft. steel radio tower at the Naval Radio station, here, from the Eureka Boiler Wks., Foot of Tea St., $6,890; Pittsburgh-Des Moines Steel Co., 959 Munsey Bldg., Washington, D. C., $7,960; and the Union Constr. Co., 807 Balfour Bldg., San Francisco,. $8,127.75. Spec. 4533.

Cal., Long Beach—The Kimball Motor Truck Co., 1700 East 9th St., is having plans prepared for auto truck factory on West Aneheon Blvd. About $350,000. Private plans.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install gas, water, sewer and underground electric system. About $100,000. Spec. 4559.

Ont., Kerwood—The Township Council A. Topping, is having surveys made for an electric light and power distribution system. About $38,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

Ont., London—The Citizens Committee, P. Pocock, Lendon Shoe Co., 326 Richmond St., is having plans prepared for an ice arena at Thames Park. About $125,000. Watt & Blackwell, Bank of Toronto, London, Archts. Want prices on ice making equipment.

Ont., Oxford Centre—The Township Council, F. G. Jackson, is having surveys made for an electric light and power distribution system. About $40,000. A. Mackenzie, 190 University Ave., Toronto, Engrs.

Ont., London—The Township Council, M. Grant, 110 Dundas St., is having surveys made for an electric light and power distribution system. About $30,000. J. N. Nelson, 190 University Ave., Engr.

Ont., Muncey—The Township Council, J. Brodie, is having surveys made for an electric light and power distribution system. About $35,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

CONTRACTS AWARDED

Mass., Everett—Malden Elec. Co. has awarded the contract for a 1 story 63 x 66 ft. sub-station on Bway. and Oakland St. to the Hadson Constr. Co., 6 Beacon St., Boston. About $65,000.

Mass., Fall River—The Hospital Comm., has awarded the contract for a 2 story hospital on Bedford St. to A. Macdougall, 859 Robeson St. About $700,000. Noted Mar. 9.

N. Y., New York—The Bd. Educ., 500 Park Ave., has awarded the contract for a heating and ventilating system for P. S. No. 115 on West 176th St. and 177th St. between Audubon and St. Nicholas Aves. to E. Rutzler Co., 404 East 49th St., $18,189. Noted Nov. 15.

N. Y., New York—The Intercollegiate Cosmopolitan Club of Y. M. C. A., has awarded the contract for a 12 story club and recreation bldg. on Claremont Ave. near 12th St. to M. Eidletz, 33 East 42nd St. About $1,500,000.

Pa., Pittsburgh—The Manoa Realty Co. will build an 8 story, 91 x 160 ft. apartment on Ruskin Ave. About $1,000,000. Owner will build by separate contracts.

N. Y., New York—The One Hundred and Fourteen West 70th St. Corp., c/o Somerfield & Steckler, Archts., 31 Union Sq., will build a 9 story apartment at 114 West 70th St. About $450,000. Owner will build by day labor.

N. J., Atlantic City—The Shelburne Hotel, c/o Warren & Wetmore, Archts., 10 East 42nd St., New York City has awarded the contract for an 8 story, 70 x 185 ft. addition to hotel on South Michigan Ave. to G. A. Fuller Co., Walnut St., Phila., Pa. About $600,000. Noted April 26.

Md., Baltimore — Church Home & Infirmary of Baltimore City will soon award the contract for a service building. About $500,000. Wyatt & Nolting, Keyser Bldg., Archts. Noted July 26.

W. Va., East Wheeling—The Whitaker-Glessner Co., Manchester St., Wheeling, will build a boiler and power house at their plant here and install four 823 hp. boilers and two 600 kw. generators, also make additions and alterations to present plant.

Ill., Chicago—The Bd. Educ., 650 South Clark St., has awarded the contract for a 3 story, 157 x 276 ft. school at 9900-30 Ave. H to S. Nelson, 3050 Augusta St. About $600,000. A steam heating system will be installed. Noted Sept. 20.

Wis., Ashkosh—The city has awarded the contract for a street lighting system to the Monroe Electric Co., 159 North State St., Chicago, Ill. About $40,525.57.

Wis., Milwaukee—The Sewerage Comm., City Hall, has awarded the contract for coal handling equipment for boiler house at Jones Island to the Chain Belt Co., 736 Park St., $32,700. The ash handling to the Conveyors Corp. of Amer., 326 West Madison St., Chicago, Ill., $19,581. Noted Oct. 25.

Kan., Lawrence — The Bd. Educ., C. E. Esterly, Secy., has awarded the contract for a 3 story school to A. H. Newmann & Co., 6th and Locust Sts., Des Moines, Ia., $495,000. Noted Nov. 15.

Tex., Dallas—The city has awarded the contract for furnishing and erecting pumping equipment for the White Rock filtration plant to A. M. Lockett, 521 Barrone St., New Orleans, La., $28,691. Noted Oct. 25.